WIRING AND PROTECTIONS

CHAPTER - 4

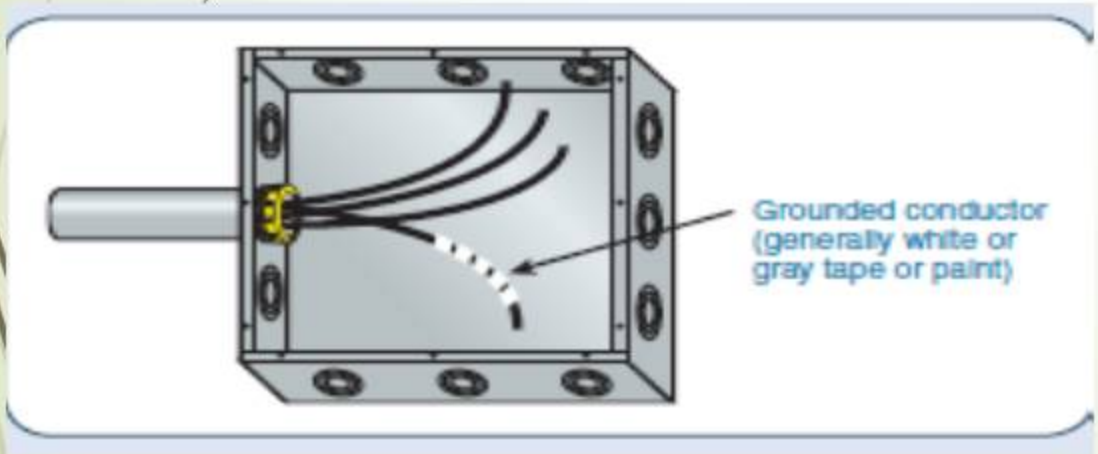
Contents

Article 2.0
Use and Identification of Grounded Conductors

Grounded Conductor

A system or circuit conductor that is intentionally grounded. (Article 1.1)

Note: Not to be confused with *Grounding Conductor*.



MEANS OF IDENTIFYING GROUNDED CONDUCTORS

Sizes 14 mm^2 or Smaller

- shall be identified by a continuous white or gray outer finish or by three continuous white stripes on other than green insulation along its entire length.

Insulated grounded conductors shall be identified as follows:

- mineral-insulated, metal sheathed cable shall be identified at the time of installation by distinctive marking at its terminations.

MEANS OF IDENTIFYING GROUNDED CONDUCTORS

Insulated grounded conductors shall be identified as follows:

- A single-conductor, sunlight-resistant, outdoor-rated cable used in photovoltaic power systems shall be identified at the time of installation by distinctive white marking at all terminations.

MEANS OF IDENTIFYING GROUNDED CONDUCTORS

Sizes Larger Than 14 mm^2

- shall be identified by one of the following means:
  - continuous white or gray outer finish.
  - three continuous white stripes along its entire length on other than green insulation.
  - a distinctive white or gray marking at its terminations. This marking shall encircle the conductor or insulation.

Flexible Cords

- An insulated conductor that is intended for use as a grounded conductor, shall be identified by a white or gray outer finish

MEANS OF IDENTIFYING GROUNDED CONDUCTORS

Grounded Conductors of Different Systems

Identification that distinguishes each system grounded conductor shall be permitted by one of the following means:

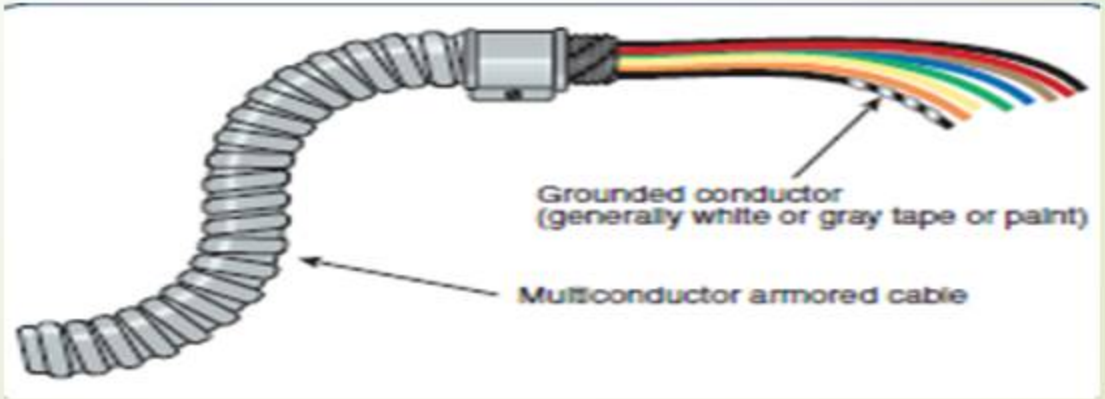
- One system grounded conductor shall have an outer covering
- The grounded conductor(s) of other systems shall have a different outer covering or by an outer covering of white or gray with a readily distinguishable colored stripe other than green running along the insulation.

- This means of identification shall be permanently posted at each branch-circuit panelboard.

MEANS OF IDENTIFYING GROUNDED CONDUCTORS

Grounded Conductors of Multiconductor Cables

- shall be identified by a continuous white or gray outer finish or by three continuous white stripes on other than green insulation along its entire length.



IDENTIFICATION OF TERMINALS

Receptacles, Plugs, and Connectors

- shall have the terminal intended for connection to the grounded conductor identified as follows:
  - Identification shall be by a metal or metal coating that is substantially white in color or by the word white or the letter W located adjacent to the identified terminal
  - If the terminal is not visible, the conductor entrance hole for the connection shall be colored white or marked with the word white or the letter W.

IDENTIFICATION OF TERMINALS

Screw Shells.

- For devices with screw shells, the terminal for the grounded conductor shall be the one connected to the screw shell.

Screw Shell Devices with Leads.

- For screw shell devices with attached leads, the conductor attached to the screw shell shall have a white or gray finish. The outer finish of the other conductor shall be of a solid color that will not be confused with the white or gray finish used to identify the grounded conductor.

IDENTIFICATION OF TERMINALS

Appliances

- have a single-pole switch or a single-pole overcurrent device in the line or any line-connected screw shell lampholders, and that are to be connected by:
  - a permanent wiring method or
  - field-installed attachment plugs and cords with three or more wires (including the equipment grounding conductor), shall have means to identify the terminal for the grounded circuit conductor (if any).

Polarity of Connections

- No grounded conductor shall be attached to any terminal or lead so as to reverse the designated polarity.

Article 2.10
BRANCH CIRCUITS

SCOPE

- Covers branch circuits **except** branch circuits that supply ***only motor loads.*** (see Art. 4.30)

- Provision of this Article along with Article 4.30 will be used for branch circuits with combination loads.

RATING

- Branch circuits recognized in this article are rated accordance with the maximum permitted ampere rating of the OC device.
- The rating for other than individual branch circuits shall be 15, 20, 30, 40, and 50 amperes.
- Where conductors of higher ampacity are used for any reason, the ampere rating or setting of the specified overcurrent device shall determine the circuit rating.

MULTIWIRE BRANCH CIRCUITS

General

- Branch circuits recognized by this article shall be permitted as multiwire circuits.
- A multiwire circuit shall be permitted to be considered as multiple circuits.
- All conductors shall originate from the same panelboard or similar distribution equipment.

MULTIWIRE BRANCH CIRCUITS

Devices or Equipment

- Where a multiwire branch circuit supplies more than one device or equipment on the same yoke, a means shall be provided to disconnect simultaneously all ungrounded conductors supplying those devices or equipment at the point where the branch circuit originates.

MULTIWIRE BRANCH CIRCUITS

Line-to-Neutral Loads

- Multiwire branch circuits shall supply only line-to-neutral loads.

- *Exception No. 1: A multiwire branch circuit that supplies only one utilization equipment.*
- *Exception No. 2: Where all ungrounded conductors of the multiwire branch circuit are opened simultaneously by the branch-circuit overcurrent device.*

IDENTIFICATION FOR BRANCH CIRCUITS

Grounded Conductor

- The grounded conductor of a branch circuit shall be identified in accordance with **Means of Identifying Grounded Conductors.**

Equipment Grounding Conductor

- The equipment grounding conductor shall be identified in accordance with **Identification of Equipment Grounding Conductors.**

IDENTIFICATION FOR BRANCH CIRCUITS

Ungrounded Conductors

- The means of identification shall be permitted to be by separate color coding, marking tape, tagging, or other approved means and shall be permanently posted at each branch-circuit panelboard or similar branch-circuit distribution equipment.

IDENTIFICATION FOR BRANCH CIRCUITS

Branch-Circuit Voltage Limitations

- The nominal voltage of branch circuits shall not exceed the values permitted by:
  - **Occupancy Limitation**
    - In dwelling units and guest rooms or guest suites of hotels, motels, and similar occupancies, the voltage shall not exceed 230 volts, nominal, between conductors that supply the terminals of the following:
      - Luminaires (lighting fixtures)
      - Cord-and-plug-connected loads 1440 volt-amperes, nominal,or less or less than ¼ hp

IDENTIFICATION FOR BRANCH CIRCUITS

Branch-Circuit Voltage Limitations

- **230 Volts Between Conductors**
  - Circuits not exceeding 230 volts, nominal, between conductors shall be permitted to supply the following:
    - The terminals of lampholders applied within their voltage ratings
    - Auxiliary equipment of electric-discharge lamps
    - Cord-and-plug-connected or permanently connected utilization equipment

IDENTIFICATION FOR BRANCH CIRCUITS

Branch-Circuit Voltage Limitations

- **277 Volts to Ground**
  - shall be permitted to supply the following:
    1. Listed electric-discharge luminaires (lighting fixtures)
    2. Listed incandescent luminaires
    3. Luminaires
    4. Lampholders
    5. Auxiliary equipment of electric-discharge lamps
    6. Cord-and-plug-connected or permanently connected utilization equipment

BRANCH CIRCUIT RECEPTACLE REQUIREMENTS

- **Receptacle Outlet Location**
  - Receptacle outlets shall be located in branch circuits
- **Multiple Branch Circuits**
  - Where two or more branch circuits supply devices or equipment on the same yoke, a means to simultaneously disconnect the ungrounded conductors supplying those devices shall be provided at the point at which the branch circuits originate.

GROUND-FAULT CIRCUIT-INTERRUPTER PROTECTION FOR PERSONNEL

Dwelling Units

- All 125-volt and/or 250 volts, single-phase, 15- and 20-ampere receptacles shall have ground-fault circuit interrupter protection for personnel.
  1. Bathrooms
  2. Garages, and also accessory buildings that have a floor located at or below grade level not intended as habitable rooms and limited to storage areas, work areas, and areas of similar use

EXHIBIT 210.8 A 15-ampere duplex receptacle with integral GFCI that also protects downstream loads.

GROUND-FAULT CIRCUIT-INTERRUPTER PROTECTION FOR PERSONNEL

Dwelling Units

1. Outdoors
2. Crawl spaces — at or below grade level
3. Unfinished basements — for purposes of this section, unfinished basements are defined as portions or areas of the basement not intended as habitable rooms and limited to storage areas, work areas, and the like
4. Kitchens — where the receptacles are installed to serve the countertop surfaces
5. Laundry, utility, and wet bar sinks — where the receptacles are
6. installed within 1 800 mm of the outside edge of the sink
7. Boathouses

GROUND-FAULT CIRCUIT-INTERRUPTER PROTECTION FOR PERSONNEL

- **Other Than Dwelling Units**
  - All 125-volt and/or 250 volts, single-phase, 15- and 20-ampere receptacles installed in the locations specified in (1) through (5) shall have ground-fault circuit-interrupter protection for personnel:

1. Bathrooms
2. Commercial and institutional kitchens — for the purposes of this section, a kitchen is an area with a sink and permanent facilities for food preparation and cooking
3. Rooftops
4. Outdoors in public spaces—for the purpose of this section a public space is defined as any space that is for use by, or is accessible to, the public
5. Outdoors

GROUND-FAULT CIRCUIT-INTERRUPTER PROTECTION FOR PERSONNEL

Boat Hoists

- Ground-fault circuit-interrupter protection for personnel shall be provided for outlets that supply boat hoists installed in dwelling unit locations and supplied by 125-volt and/or 250 volts, 15- and 20-ampere branch circuits.

Circuits Derived from Autotransformers

- Branch circuits shall not be derived from autotransformers unless the circuit supplied has a grounded conductor that is electrically connected to a grounded conductor of the system supplying the autotransformer.

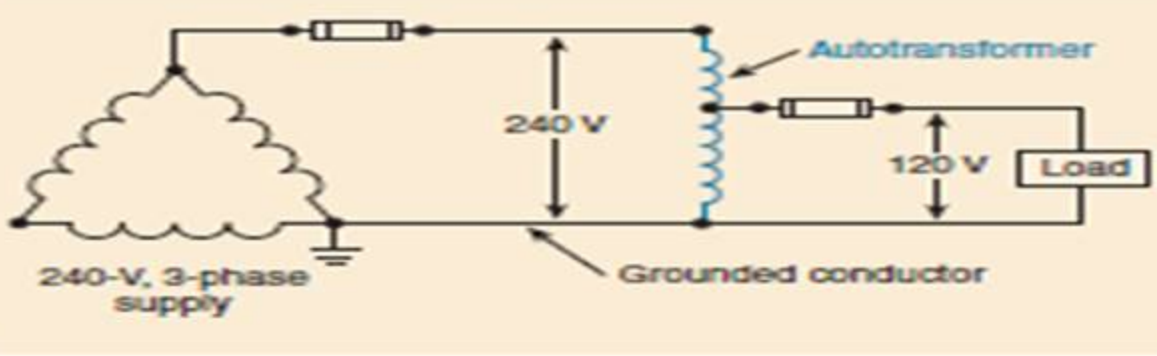


EXHIBIT 210.17 *Circuitry for an autotransformer used to derive a 2-wire, 120-volt system for lighting or convenience receptacles from a 240-volt corner-grounded delta system.*

Branch Circuits Required

- Branch circuits for lighting and for appliances, including motor-operated appliances, shall be provided to supply the loads.

Number of Branch Circuits

- The minimum number of branch circuits shall be determined from the total calculated load and the size or rating of the circuits used. In all installations, the number of circuits shall be sufficient to supply the load served. In no case shall the load on any circuit exceed the maximum.

Branch Circuits Required

Dwelling Units

- Small-Appliance Branch Circuits
  - In addition to the number of branch circuits required by other parts of this section, two or more 20- ampere small-appliance branch circuits shall be provided for all receptacle outlets
- Laundry Branch Circuits
  - In addition to the number of branch circuits required by other parts of this section, at least one additional 20-ampere branch circuit shall be provided to supply the laundry receptacle outlet(s). This circuit shall have no other outlets.

Branch Circuits Required

Dwelling Units

- Bathroom Branch Circuits
  - In addition to the number of branch circuits required by other parts of this section, at least one 20-ampere branch circuit shall be provided to supply bathroom receptacle outlet(s). Such circuits shall have no other outlets.

Arc-Fault Circuit-Interrupter Protection

- device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.

Dwelling Unit Bedrooms

- All 115-volt and/or 230-volt, single phase, 15- and 20-ampere branch circuits supplying outlets installed in dwelling unit bedrooms shall be protected by a listed arc-fault circuit interrupter, combination type installed to provide protection of the branch circuit.

EXHIBIT 210.22 The required marking indicating the type of AFCI protection afforded by this circuit breaker.

Arc-Fault Circuit-Interrupter Protection

Exceptions:

(a) The arc-fault circuit interrupter installed within 1800 mm of the branch circuit overcurrent device as measured along the branch circuit conductors.

(b) The circuit conductors between the branch circuit overcurrent device and the arc-fault circuit interrupter shall be installed in a metal raceway or a cable with a metallic sheath.

Guest Rooms and Guest Suites

- Guest rooms and guest suites that are provided with permanent provisions for cooking shall have branch circuits and outlets installed to meet the rules for dwelling units.

Branch-Circuit Ratings

Conductors — Minimum Ampacity and Size Branch Circuits Not More Than 600 Volts

- General
  - Branch-circuit conductors shall have an ampacity not less than the maximum load to be served.
  - Where a branch circuit supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum branch-circuit conductor size, before the application of any adjustment or correction factors, shall have an allowable ampacity not less than the noncontinuous load plus 125 percent of the continuous load.

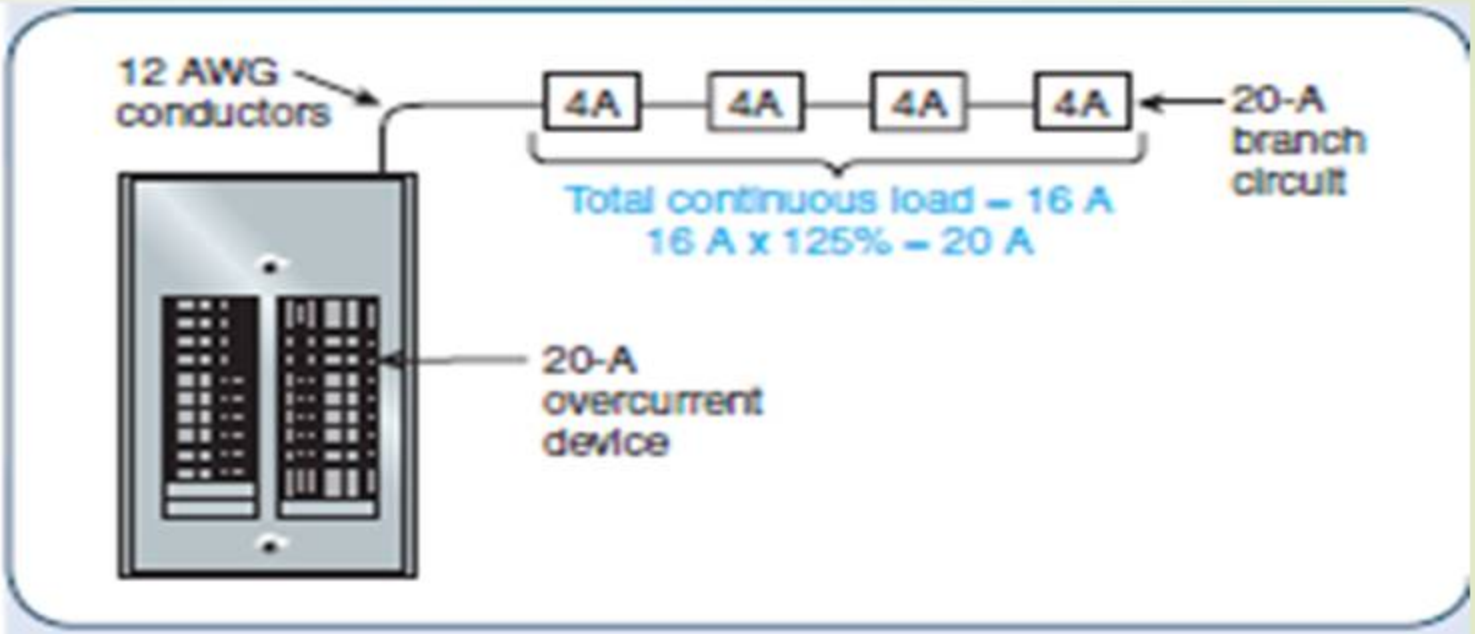


EXHIBIT 210.25 *A continuous load (store lighting) calculated at 125 percent to determine the ampacity of the conductor and the branch-circuit size.*

Branch-Circuit Ratings

Conductors Minimum Ampacity and Size

Branch Circuits Not More Than 600 Volts

- Household Ranges and Cooking Appliances
  - Branch-circuit conductors supplying household ranges, wall-mounted ovens, countermounted cooking units, and other household cooking appliances shall have an ampacity not less than the rating of the branch circuit and not less than the maximum load to be served. For ranges of 8¾ kW or more rating, the minimum branch-circuit rating shall be 40 amperes.

Branch-Circuit Ratings

Conductors — Minimum Ampacity and Size

Branch Circuits Not More Than 600 Volts

- Other Loads
  - Branch-circuit conductors that supply loads other than cooking appliances shall have an ampacity sufficient for the loads served and **shall not be smaller than 2.0 mm^2 (1.6 mm dia.).**

Branch-Circuit Ratings

Conductors Minimum Ampacity and Size

Branch Circuits Over 600 Volts

- General
  - The ampacity of branch-circuit conductors shall not be less than 125 percent of the designed potential load of utilization equipment that will be operated simultaneously.

Branch-Circuit Ratings

Overcurrent Protection

- **Continuous and Non-continuous Loads**
  - the rating of the overcurrent device shall not be less than the non-continuous load plus 125 percent of the continuous load.
- **Conductor Protection**
  - Conductors shall be protected
  - Flexible cords and fixture wires shall be protected .
- **Equipment**
  - The rating or setting of the overcurrent protective device shall not exceed that specified in the applicable articles referenced for equipment.

Branch-Circuit Ratings

Overcurrent Protection

- **Outlet Devices**
  - The rating or setting shall not exceed that specified for outlet devices.
  - **Lampholders**
    - Where connected to a branch circuit having a rating in excess of 20 amperes, lampholders shall be of the heavy-duty type
    - A heavy-duty lampholder shall have a rating of not less than 660 watts if of the medium type, or not less than 750 watts if of any other type.

Branch-Circuit Ratings

Overcurrent Protection

- **Outlet Devices**
  - **Receptacles**
    - Single Receptacle on an Individual Branch Circuit
      - A single receptacle installed on an individual branch circuit shall have an ampere rating not less than that of the branch circuit.
    - Total Cord-and-Plug-Connected Load
      - Where connected to a branch circuit supplying two or more receptacles or outlets, a receptacle shall not supply a total cord-and-plug-connected load in excess of the maximum specified in Table 2.10.2.3(b)(2).

Branch-Circuit Ratings

Overcurrent Protection

- **Outlet Devices**
  - **Receptacles**
    - Receptacle Ratings
      - Where connected to a branch circuit supplying two or more receptacles or outlets, receptacle ratings shall conform to the values listed in Table 2.10.2.3(b)(3), or where larger than 50 amperes, the receptacle rating shall not be less than the branch-circuit rating.
    - Range Receptacle Rating
      - The ampere rating of a range receptacle shall be permitted to be based on a single range demand load as specified in Table 2.20.3.16.

Table 2.10.2.3(b)(3)

Table 2.10.2.3(b)(3) Receptacle Ratings for Various Size Circuits

Circuit Rating (Amperes)	Receptacle Rating (Amperes)
15	Not over 15
20	15 or 20
30	30
40	40 or 50
50	50

Table 2.20.3.16

Table 2.20.3.16 Demand Factors and Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over 1¾ kW Rating (Column C to be used in all cases except as otherwise permitted in Note 3.)

Number of Appliances	Demand Factor (Percent) (See Notes)		Column C Maximum Demand (kW) (See Notes) (Not over 12 kW Rating)
	Column A (Less than 3½ kW Rating)	Column B (3½ kW to 8¾ kW Rating)	
1	80	80	8
2	75	65	11
3	70	55	14
4	66	50	17
5	62	45	20
6	59	43	21
7	56	40	22
8	53	36	23
9	51	35	24
10	49	34	25
11	47	32	26
12	45]	32	27
13	43	32	28
14	41	32	29
15	40	32	30

Branch-Circuit Ratings

15- and 20-Ampere Branch Circuits

- shall be permitted to supply lighting units or other utilization equipment, or a combination of both, and shall comply with:
  - **Cord-and-Plug-Connected Equipment Not Fastened in Place.** shall not exceed 80 percent of the branch-circuit ampere rating.
  - **Utilization Equipment Fastened in Place.** shall not exceed 50 percent of the branch-circuit ampere rating where lighting units, cord-and-plug-connected utilization equipment not fastened in place, or both, are also supplied.

Branch-Circuit Ratings

- **30-Ampere Branch Circuits**
  - supply fixed lighting units with heavy-duty lampholders in other than a dwelling unit(s) or utilization equipment in any occupancy. Shall not exceed 80 percent of the branch-circuit ampere rating.
- **40- and 50-Ampere Branch Circuits**
  - to supply cooking appliances that are fastened in place in any occupancy.
- **Branch Circuits Larger Than 50 Amperes**
  - shall supply only nonlighting outlet loads.

Branch-Circuit Ratings

- **Common Area Branch Circuits**
  - Branch circuits in dwelling units shall supply only loads within that dwelling unit or loads associated only with that dwelling unit
  - Branch circuits required for the purpose of lighting, central alarm, signal, communications, or other needs for public or common areas of a two-family or multifamily dwelling shall not be supplied from equipment that supplies an individual dwelling unit

Required Outlets

- **Cord Pendants**
  - A cord connector that is supplied by a permanently connected cord pendant shall be considered a receptacle outlet.
- **Cord Connections**
  - A receptacle outlet shall be installed wherever flexible cords with attachment plugs are used. Where flexible cords are permitted to be permanently connected, receptacles shall be permitted to be omitted for such cords.
- **Appliance Outlets**
  - Appliance receptacle outlets installed in a dwelling unit for specific appliances, such as laundry equipment, shall be installed within 1 800 mm of the intended location of the appliance.

Required Outlets
Dwelling Unit Receptacle Outlets

- This section provides requirements for 125-volt, 15- and 20-ampere receptacle outlets. Receptacle outlets required by this section shall be in addition to any receptacle that is part of a luminaire (lighting fixture) or appliance, located within cabinets or cupboards, or located more than 1 700 mm above the floor.

Required Outlets

Dwelling Unit Receptacle Outlets

- **General Provisions**
  - receptacle outlets shall be installed in accordance with the general provisions specified :
    - Spacing
      - Receptacles shall be installed so that no point measured horizontally along the floor line in any wall space is more than 1 800 mm from a receptacle outlet.

Required Outlets

Dwelling Unit Receptacle Outlets

- **General Provisions**
  - Floor Receptacles
    - Receptacle outlets in floors shall not be counted as part of the required number of receptacle outlets unless located within 450 mm of the wall.

Required Outlets

Small Appliances

- Receptacle Outlets Served
  - In the kitchen, pantry, breakfast room, dining room, or similar area of a dwelling unit, the two or more 20-ampere small-appliance branch circuits shall serve all wall and floor receptacle outlets all countertop outlets, and receptacle outlets for refrigeration equipment.
- No Other Outlets
  - The two or more small appliance branch circuits shall have no other outlets.

Required Outlets

Small Appliances

- Kitchen Receptacle Requirements
  - Receptacles installed in a kitchen to serve countertop surfaces shall be supplied by not fewer than two small-appliance branch circuits, either or both of which shall also be permitted to supply receptacle outlets in the same kitchen and in other rooms.
  - Additional small-appliance branch circuits shall be permitted to supply receptacle outlets in the kitchen and other rooms.
  - No small appliance branch circuit shall serve more than one kitchen.

Required Outlets

Countertops:

- Wall Counter Spaces
  - A receptacle outlet shall be installed at each wall counter space that is 300 mm or wider.
  - Receptacle outlets shall be installed so that no point along the wall line is more than 600 mm measured horizontally from a receptacle outlet in that space.
- Island Counter Spaces
  - At least one receptacle shall be installed at each island counter space with a long dimension of 600 mm or greater and a short dimension of 300 mm or greater.
  - Where a rangetop or sink is installed in an island counter and the width of the counter behind the rangetop or sink is less than 300 mm, the rangetop or sink is considered to divide the island into two separate countertop.

Required Outlets

Countertops

- Peninsular Counter Spaces
  - At least one receptacle outlet shall be installed at each peninsular counter space with a long dimension of 600 mm or greater and a short dimension of 300 mm or greater. A peninsular countertop is measured from the connecting edge.
- Separate Spaces
  - Countertop spaces separated by rangetops, refrigerators, or sinks shall be considered as separate countertop spaces
- Receptacle Outlet Location
  - Receptacle outlets shall be located above, but not more than 500 mm above, the countertop.

Required Outlets

- **Bathrooms**
  - In dwelling units, at least one receptacle outlet shall be installed in bathrooms within 900 mm of the outside edge of each basin.
  - The receptacle outlet shall be located on a wall or partition that is adjacent to the basin or basin countertop.
- **Outdoor Outlets**
  - For a one-family dwelling and each unit of a two-family dwelling that is at grade level, at least one receptacle outlet accessible at grade level and not more than 2 000 mm above grade shall be installed at the front and back of the dwelling.

Required Outlets

- **Laundry Areas**
  - In dwelling units, at least one receptacle outlet shall be installed for the laundry.
- **Basements and Garages**
  - For a one-family dwelling, at least one receptacle outlet, in addition to any provided for laundry equipment, shall be installed in each basement and in each attached garage, and in each detached garage with electric power.
- **Hallways**
  - In dwelling units, hallways of 3 000 mm or more in length shall have at least one receptacle outlet.

Required Outlets

Guest Rooms or Guest Suites

- **General**
  - Guest rooms or guest suites in hotels, motels, and similar occupancies shall have receptacle outlets installed.
  - Guest rooms or guest suites provided with permanent provisions for cooking shall have receptacle outlets installed
- **Receptacle Placement**
  - These receptacle outlets shall be permitted to be located conveniently for permanent furniture layout.
  - At least two receptacle outlets shall be readily accessible.
  - Where receptacles are installed behind the bed, the receptacle shall be located to prevent the bed from contacting any attachment plug that may be installed or the receptacle shall be provided with a suitable guard.

Required Outlets

- **Show Windows**
  - At least one receptacle outlet shall be installed directly above a show window for each 3600 linear mm or major fraction thereof of show window area measured horizontally at its maximum width.
- **Heating, Air-Conditioning, and Refrigeration Equipment Outlet**
  - A 125-volt and/or 250 volts, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed at an accessible location for the servicing of heating, air-conditioning, and refrigeration equipment.
  - The receptacle shall be located on the same level and within 7600 mm of the heating, air-conditioning, and refrigeration equipment.
  - The receptacle outlet shall not be connected to the load side of the equipment disconnecting means.

Required Outlets

- **Dwelling Units**
  - In dwelling units, lighting outlets shall be installed in accordance with:
  - Habitable Rooms

    At least one wall switch-controlled lighting outlet shall be installed in every habitable room
  - Additional Locations
    - Additional lighting outlets shall be installed in accordance with:
      - At least one wall switch-controlled lighting outlet shall be installed in hallways, stairways, attached garages, and detached garages with electric power.

- For dwelling units, attached garages, and detached garages with electric power, at least one wall switch–controlled lighting outlet shall be installed to provide illumination on the exterior side of outdoor entrances or exits with grade level access.
- A vehicle door in a garage shall not be considered as an outdoor entrance or exit.
- Where one or more lighting outlet(s) are installed for interior stairways, there shall be a wall switch at each floor level, and landing level that includes an entryway, to control the lighting outlet(s) where the stairway between floor levels has six risers or more.

Required Outlets

- **Dwelling Units**
  - Storage or Equipment Spaces

    For attics, underfloor spaces, utility rooms, and basements, at least one lighting outlet containing a switch or controlled by a wall switch shall be installed where these spaces are used for storage or contain equipment requiring servicing.
  - At least one point of control shall be at the usual point of entry to these spaces.
  - The lighting outlet shall be provided at or near the equipment requiring servicing.
- **Guest Rooms or Guest Suites**
  - In hotels, motels, or similar occupancies, guest rooms or guest suites shall have at least one wall switch–controlled lighting outlet installed in every habitable room and bathroom.

Required Outlets

- **Other Than Dwelling Units**
  - For attics and underfloor spaces containing equipment requiring servicing, such as heating, air-conditioning, and refrigeration equipment, at least one lighting outlet containing a switch or controlled by a wall switch shall be installed in such spaces.
  - At least one point of control shall be at the usual point of entry to these spaces.
  - The lighting outlet shall be provided at or near the equipment requiring servicing.

ARTICLE 2.15

FEEDERS

Scope

- This article covers the installation requirements, overcurrent protection requirements, minimum size, and ampacity of conductors for feeders supplying branch-circuit loads.

Minimum Rating and Size

- **Feeders Not More Than 600 Volts**
  - General
    - Feeder conductors shall have an ampacity not less than required to supply the load as calculated. The minimum feeder-circuit conductor size, before the application of any adjustment or correction factors, shall have an allowable ampacity not less than the non-continuous load plus 125 percent of the continuous load.
  - Ampacity Relative to Service Conductors
    - The feeder conductor ampacity shall not be less than that of the service conductors where the feeder conductors carry the total load supplied by service conductors with an ampacity of 55 amperes or less.
  - Individual Dwelling Unit or Mobile Home Conductors
    - Feeder conductors for individual dwelling units or mobile homes need not be larger than service conductors.

Minimum Rating and Size

- **Feeders Over 600 Volts**
  - Feeder conductors over 600 volts shall be sized in accordance with the following:
    - Feeders Supplying Transformers
      - The ampacity of feeder conductors shall not be less than the sum of the nameplate ratings of the transformers supplied when only transformers are supplied.
    - Feeders Supplying Transformers and Utilization Equipment
      - The ampacity of feeders supplying a combination of transformers and utilization equipment shall not be less than the sum of the nameplate ratings of the transformers and 125 percent of the designed potential load of the utilization equipment that will be operated simultaneously.

Overcurrent Protection

- Feeders shall be protected against overcurrent.
- Where a feeder supplies continuous loads or any combination of continuous and non-continuous loads, the rating of the overcurrent device shall not be less than the non-continuous load plus 125 percent of the continuous load.

Diagrams of Feeders

If required by the authority having jurisdiction, a diagram showing feeder details shall be provided prior to the installation of the feeders. Such a diagram shall show:

- the area in square feet of the building or other structure supplied by each feeder,
- the total calculated load before applying demand factors,
- the demand factors used,
- the calculated load after applying demand factors,
- and the size and type of conductors to be used.

Ground-Fault Circuit-Interrupter Protection for Personnel

- Feeders supplying 15- and 20-ampere receptacle branch circuits shall be permitted to be protected by a ground-fault circuit interrupter in lieu of the provisions for such interrupters.

ARTICLE 2.20

BRANCH-CIRCUIT, FEEDER, AND SERVICE CALCULATIONS

General

Scope

- This article provides requirements for calculating branch-circuit, feeder, and service loads.

Calculations

- **Voltages**

  Unless other voltages are specified, for purposes of calculating branch-circuit and feeder loads, nominal system voltages of 115, 115/230, 208Y/120, 230, 347, 400Y/230, 460Y/265, 460, 600Y/347, and 600 volts shall be used.

- **Fractions of an Ampere**

  Where calculations result in a fraction of an ampere that is less than 0.5, such fractions shall be permitted to be dropped.

Branch Circuit Load Calculations

- **Lighting Load for Specified Occupancies**
  - A unit load of not less than that specified in Table 2.20.2.3 for occupancies specified therein shall constitute the minimum lighting load.
  - The floor area for each floor shall be calculated from the outside dimensions of the building, dwelling unit, or other area involved.
  - For dwelling units, the calculated floor area shall not include open porches, garages, or unused or unfinished spaces not adaptable for future use.

Table 2.20.2.3

Table 2.20.2.3 General Lighting Loads by Occupancy

Type of Occupancy	Unit Load Volt-Amperes per Square Meter
Armories and auditoriums	11
Banks	39[b]
Barber shops and beauty parlors	33
Churches	11
Clubs	22
Court rooms	22
Dwelling units[a]	33
Garages — commercial (storage)	6
Hospitals	22
Hotels and motels, including apartment houses without provision for cooking by tenants[a]	22
Industrial commercial (loft) buildings	22
Lodge rooms	17
Office buildings	39[b]
Restaurants	22
Schools	33
Stores	33
Warehouses (storage)	3
In any of the preceding occupancies except one-family dwellings and individual dwelling units of two-family and multifamily dwellings:	
Assembly halls and auditoriums	11
Halls, corridors, closets, stairways	6
Storage spaces	3

[a]See 2.20.2.5(j).
[b]See 2.20.2.5(k).

Branch Circuit Load Calculations

- **Other Loads — All Occupancies**
- In all occupancies, the minimum load for each outlet for general-use receptacles and outlets not used for general illumination shall not be less than that calculated in **a)** through **l)**, the loads shown being based on nominal branch-circuit voltages.

a) Specific Appliances or Loads

- An outlet for a specific appliance or other load not covered in **b)** through **l)** shall be calculated based on the ampere rating of the appliance or load served.

Branch Circuit Load Calculations

Other Loads — All Occupancies

b) Electric Dryers and Household Electric Cooking Appliances

- Load calculations shall be permitted as specified in **Electric Clothes Dryers — Dwelling Unit(s)** for electric dryers and in **Electric Ranges and Other Cooking Appliances — Dwelling Unit(s)** for electric ranges and other cooking appliances.

c) Motor Loads

- Outlets for motor loads shall be calculated in accordance with the requirements in **Single Motor**, **Several Motors or a Motor(s) and Other Load(s)**, and **Ampacity and Rating**.

Branch Circuit Load Calculations

- **Other Loads — All Occupancies**

d) Luminaires (Lighting Fixtures)

- An outlet supplying luminaire(s) [lighting fixture(s)] shall be calculated based on the maximum volt-ampere rating of the equipment and lamps for which the luminaire(s) [fixture(s)] is rated.

e) Heavy-Duty Lampholders

- Outlets for heavy-duty lampholders shall be calculated at a minimum of 600 volt-amperes.

f) Sign and Outline Lighting

- Sign and outline lighting outlets shall be calculated at a minimum of 1200 volt-amperes for each required branch circuit specified

Branch Circuit Load Calculations

- **Other Loads — All Occupancies**

g) Show Windows

At 200 volt-amperes per 300 mm of show window

h) Fixed Multioutlet Assemblies.

Fixed multioutlet assemblies used in other than dwelling units or the guest rooms or guest suites of hotels or motels shall be calculated in accordance with (h)(1) or (h)(2).

For the purposes of this section, the calculation shall be permitted to be based on the portion that contains receptacle outlets.

Branch Circuit Load Calculations

- **Other Loads — All Occupancies**

i) Receptacle Outlets

- receptacle outlets shall be calculated at not less than 180 volt-amperes for each single or for each multiple receptacle on one yoke.

j) Dwelling Occupancies

- In one-family, two-family, and multifamily dwellings and in guest rooms or guest suites of hotels and motels, the outlets specified in (j)(1), (j)(2), and (j)(3) are included in the general lighting load calculations of 2.20.2.3.
- No additional load calculations shall be required for such outlets.

1) All general-use receptacle outlets of 20-ampere rating or less, including receptacles connected to the circuits in 2.10.1.11(c)(3)

2) The receptacle outlets specified in 2.10.3.3(e) and (g)

3) The lighting outlets specified in 2.10.3.21(a) and (b)

Branch Circuit Load Calculations

- **Other Loads — All Occupancies**

k) Banks and Office Buildings

- In banks or office buildings, the receptacle loads shall be calculated to be the larger of (1) or (2):

(1) The computed load from **Other Loads — All Occupancies**

(2) 11 volt-amperes/m^2

l) Other Outlets

- Other outlets not covered shall be calculated based on 180 volt-amperes per outlet.

Feeder and Service Load Calculations

- **General**
  - The calculated load of a feeder or service shall not be less than the sum of the loads on the branch circuits supplied, after any applicable demand factors have been applied.
- **General Lighting**
  - The demand factors specified in Table 2.20.3.3 shall apply to that portion of the total branch-circuit load calculated for general illumination. They shall not be applied in determining the number of branch circuits for general illumination.

Table 2.20.3.3

Table 2.20.3.3 Lighting Load Demand Factors

Type of Occupancy	Portion of Lighting Load to Which Demand Factor Applies (Volt-Amperes)	Demand Factor (Percent)
Dwelling units	First 3000 or less at	100
	From 3001 to 120,000 at	35
	Remainder over 120,000 at	25
Hospitals*	First 50,000 or less at	40
	Remainder over 50,000 at	20
Hotels and motels, including apartment houses without provision for cooking by tenants*	First 20,000 or less at	50
	From 20,001 to 100,000 at	40
	Remainder over 100,000 at	30
Warehouses (storage)	First 12,500 or less at	100
	Remainder over 12,500 at	50
All others	Total volt-amperes	100

*The demand factors of this table shall not apply to the calculated load of feeders or services supplying areas in hospitals, hotels, and motels where the entire lighting is likely to be used at one time, as in operating rooms, ballrooms, or dining rooms.

Feeder and Service Load Calculations

- **Show-Window and Track Lighting**

  (a) Show Windows

  - For show-window lighting, a load of not less than 660 volt-amperes/linear meter shall be included for a show window, measured horizontally along its base.

  (b) Track Lighting

  - For track lighting in other than dwelling units or guest rooms or guest suites of hotels or motels, an additional load of 150 volt-amperes shall be included for every 600 mm of lighting track or fraction thereof. Where multicircuit track is installed, the load shall be considered to be divided equally between the track circuits.

Feeder and Service Load Calculations

- **Fixed Electric Space Heating**
  - Fixed electric space heating loads shall be calculated at 100 percent of the total connected load. However, in no case shall a feeder or service load current rating be less than the rating of the largest branch circuit supplied.

Feeder and Service Load Calculations

- **Small Appliance and Laundry Loads — Dwelling Unit.**

  (a) Small Appliance Circuit Load

  - In each dwelling unit, the load shall be calculated at 1 500 volt-amperes for each 2-wire small appliance branch circuit. Where the load is subdivided through two or more feeders, the calculated load for each shall include not less than 1 500 volt-amperes for each 2-wire small appliance branch circuit. These loads shall be permitted to be included with the general lighting load and subjected to the demand factors provided in Table 2.20.3.3.

  (b) Laundry Circuit Load

  - A load of not less than 1500 voltamperes shall be included for each 2-wire laundry branch circuit installed. This load shall be permitted to be included with the general lighting load and subjected to the demand factors provided in Table 2.20.3.3.

Feeder and Service Load Calculations

- **Appliance Load — Dwelling Unit(s)**
  - It shall be permissible to apply a demand factor of 75 percent to the nameplate rating load of four or more appliances fastened in place, other than electric ranges, clothes dryers, space-heating equipment, or airconditioning equipment, that are served by the same feeder or service in a one-family, two-family, or multifamily dwelling.

Feeder and Service Load Calculations

- **Electric Clothes Dryers — Dwelling Unit(s)**
  - The load for household electric clothes dryers in a dwelling unit(s) shall be either 5 000 watts (volt-amperes) or the nameplate rating, whichever is larger, for each dryer served.
- **Electric Ranges and Other Cooking Appliances — Dwelling Unit(s)**
  - The load for household electric ranges, wall-mounted ovens, counter-mounted cooking units, and other household cooking appliances individually rated in excess of 1¾ kW shall be permitted to be calculated in accordance with Table 2.20.3.16. Kilovolt-amperes (kVA) shall be considered equivalent to kilowatts (kW) for loads calculated under this section

Table 2.20.3.16

Table 2.20.3.16 Demand Factors and Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over 1¾ kW Rating (Column C to be used in all cases except as otherwise permitted in Note 3.)

Number of Appliances	Demand Factor (Percent) (See Notes)		Column C Maximum Demand (kW) (See Notes) (Not over 12 kW Rating)
	Column A (Less than 3½ kW Rating)	Column B (3½ kW to 8¾ kW Rating)	
1	80	80	8
2	75	65	11
3	70	55	14
4	66	50	17
5	62	45	20
6	59	43	21
7	56	40	22
8	53	36	23
9	51	35	24
10	49	34	25
11	47	32	26
12	45]	32	27
13	43	32	28
14	41	32	29
15	40	32	30

Feeder and Service Load Calculations

- **Kitchen Equipment — Other Than Dwelling Unit(s).**
  - It shall be permissible to calculate the load for commercial electric cooking equipment, dishwasher booster heaters, water heaters, and other kitchen equipment in accordance with Table 2.20.3.17. These demand factors shall be applied to all equipment that has either thermostatic control or intermittent use as kitchen equipment.

Table 2.20.3.17

Table 2.20.3.17 Demand Factors for Kitchen Equipment — Other Than Dwelling Unit(s)

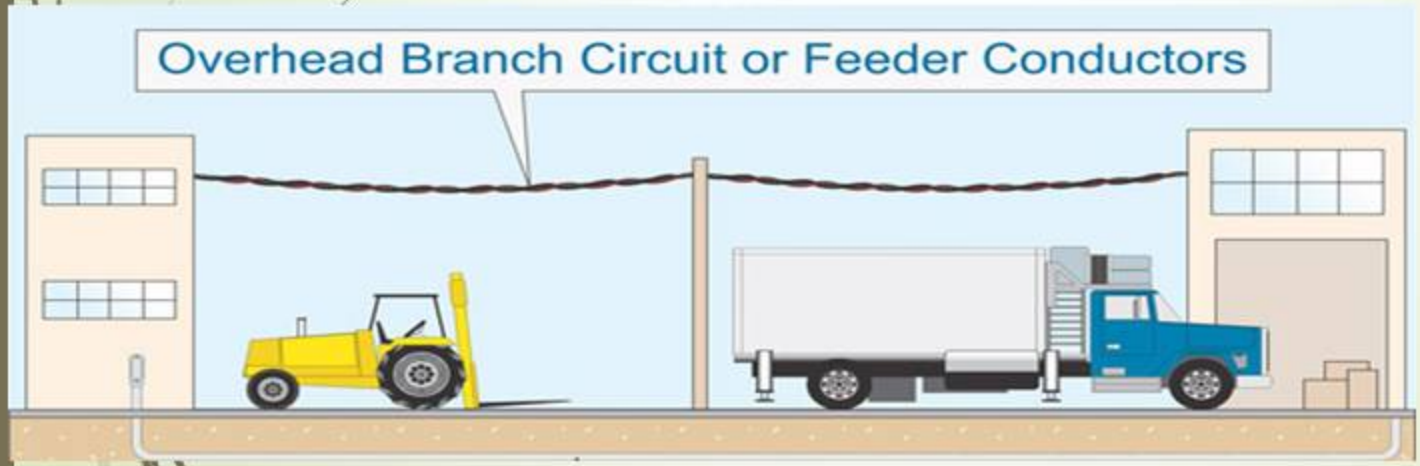
Number of Units of Equipment	Demand Factor (Percent)
1	100
2	100
3	90
4	80
5	70
6 and over	65

ARTICLE 2.25

OUTSIDE BRANCH CIRCUITS AND FEEDERS

Scope

- It covers about the requirements for outside branch circuit and feeders run on or between buildings, structures, or poles on the premises



Conductor Covering

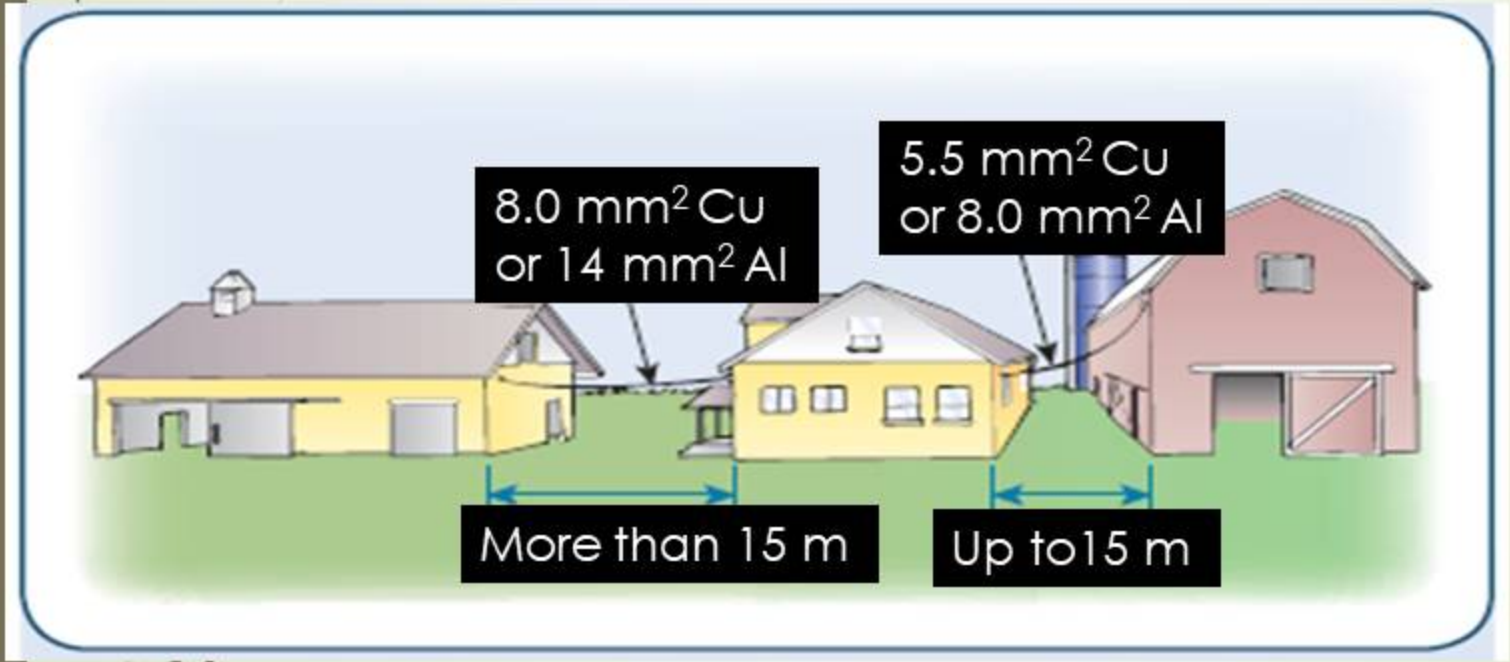
- Where within 3000 mm (10 ft) of any building or structure other than supporting poles or towers, open individual (aerial) overhead conductors shall be insulated or covered.

Conductor Size and Support

- **Overhead Spans.** conductors shall not be smaller than the following:
- for 600 volts, nominal, or less:
  - 5.5 mm^2 (2.6 mm dia.) copper or 8.0 mm^2 (3.2 mm dia.) aluminum for spans up to 15 m (50 ft) in length, and
  - 8.0 mm^2 (3.2 mm dia.) copper or 14 mm^2 aluminum for a longer span unless supported by a messenger wire

For over 600 volts, nominal,14 mm^2 copper or 22 mm^2 aluminum for individual conductors

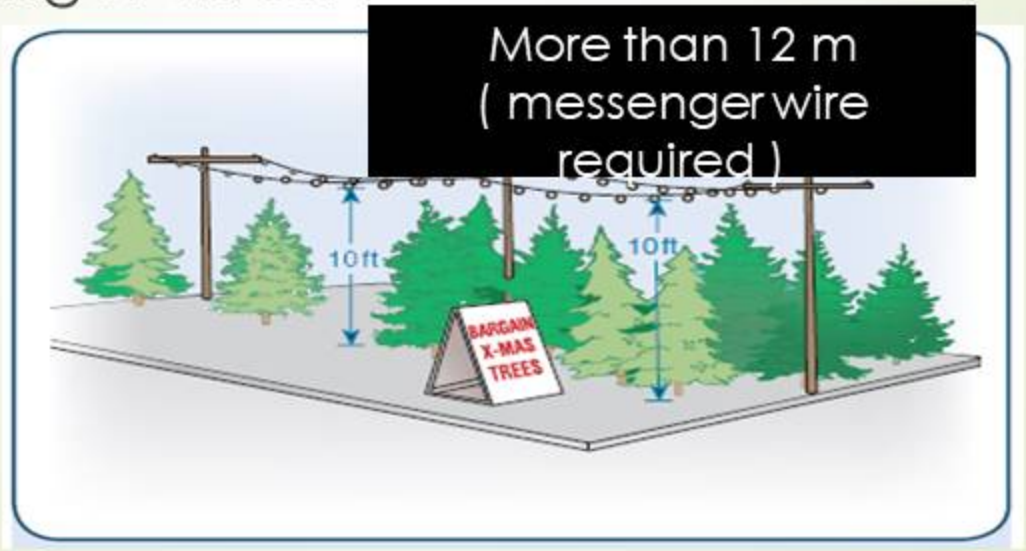
- 8.0 mm^2 (3.2 mm dia.) copper or 14 mm^2 aluminum where in cable.



Festoon Lighting

- Overhead conductors for festoon lighting shall not be smaller than 3.5 mm^2 (2.0 mm dia.) unless the conductors are supported by messenger wires.

- In all spans exceeding 12 m, the conductors shall be supported by messenger wire.



Lighting Equipment Installed Outdoors

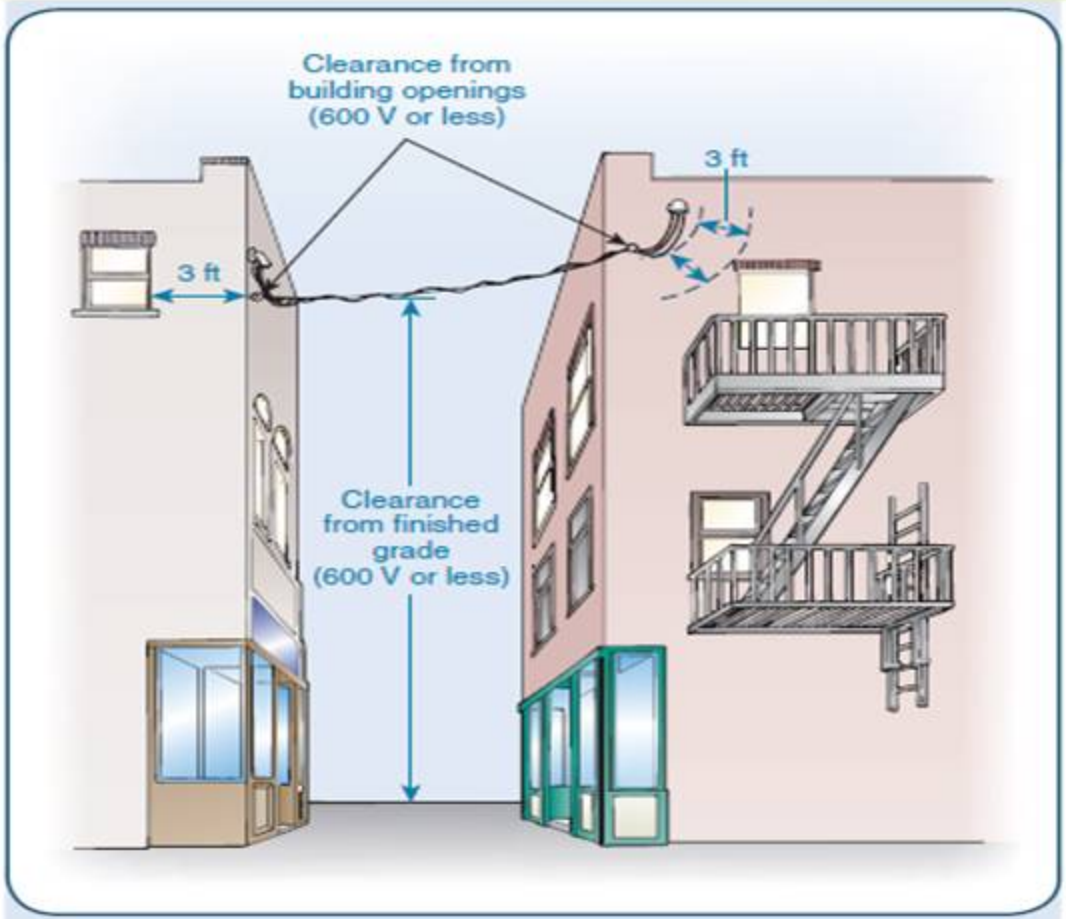
- **Common Neutral**
  - The ampacity of the neutral conductor shall not be less than the maximum net calculated load current between the neutral conductor and all ungrounded conductors
- **600 Volts Between Conductors**
  - Circuits exceeding 277 volts, nominal, to ground and not exceeding 600 volts, nominal, between conductors shall be permitted to supply the auxiliary equipment of electric-discharge lamps

Wiring on Buildings

- The installation of outside wiring on surfaces of buildings shall be permitted for circuits of not over 600 volts:
  - as multiconductor cable
  - as Type MC cable
  - as Type MI cable
  - in rigid metal conduit
  - in cable trays
  - as cablebus
  - in wireways
  - in electrical metallic tubing
  - in busways

Circuit Exits and Entrances

- Where outside branch and feeder circuits leave or enter a building, the requirements of 230.4.13 and 230.4.15 shall apply



Open-Conductor Spacing

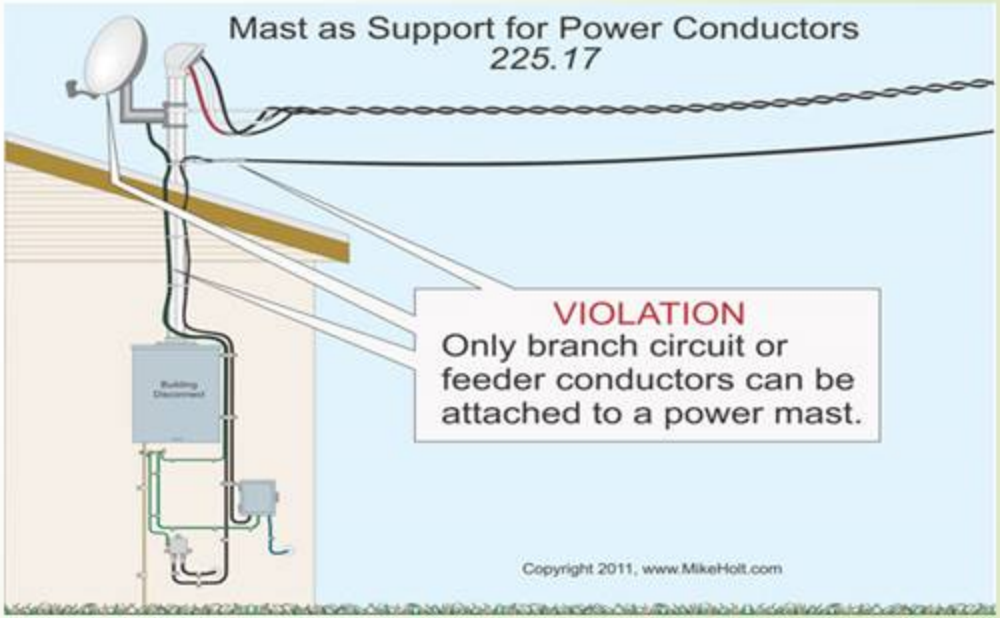
- **Separation from Other Circuits.**
  - shall be separated from open conductors of other circuits or systems by not less than 100 mm (4 in.).

Conductors on Poles.

- shall have a separation of not less than 300 mm (1 ft) where not placed on racks or brackets.
- horizontal climbing space not less than the following:
  - Power conductors below communications conductors— 750 mm (30 in.)
  - Power conductors alone or above communications conductors:
    a. 300 volts or less — 600 mm (24 in.)
    b. b. Over 300 volts — 750 mm (30 in.)

Masts as Supports

- Where a mast is used for the support of final spans of feeders or branch circuits, it shall be of adequate strength or be supported by braces or guys to withstand safely the strain imposed by the overhead drop.

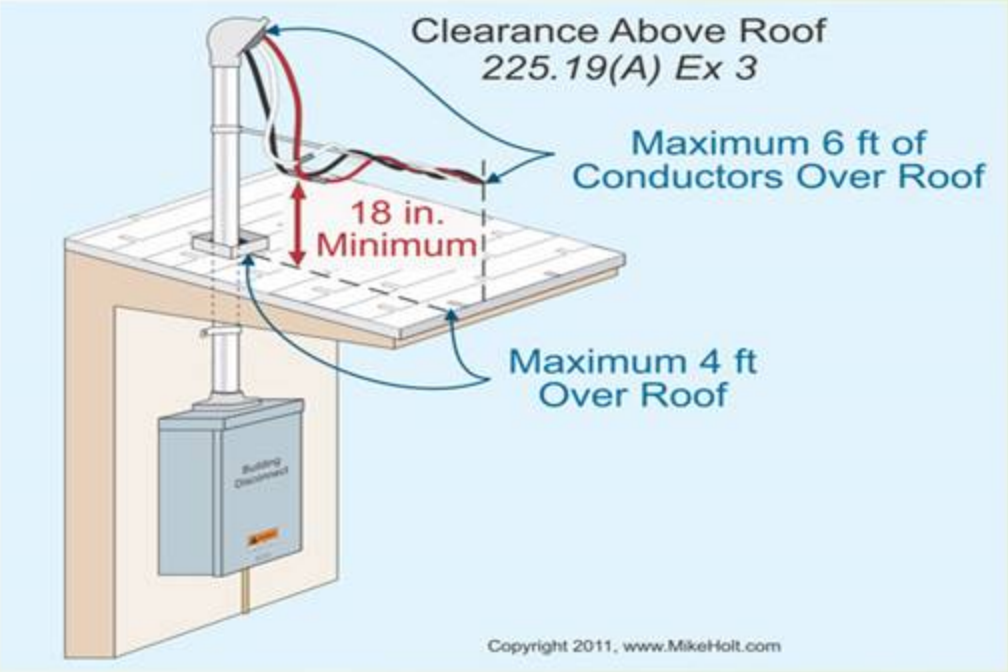


Clearance from Ground

- 3.0 m (10 ft) — where the voltage does not exceed 150 volts to ground and accessible to pedestrians only
- 3.7 m (12 ft) — over residential property and driveways, and those commercial areas, voltage does not exceed 300 volts to ground
- 4.5 m (15 ft) — for those voltage exceeds 300 volts to ground
- 5.5 m (18 ft) — over public streets, alleys, roads, parking areas subject to truck traffic, driveways
- 7.5 m (24.5 ft) — over track rails of railroads

Clearances from Buildings for Conductors of Not over 600 Volts, Nominal

- **Above Roofs.**
  - Overhead conductors must maintain a vertical clearance of 8 ft above the surface of a roof. Maintain that for a distance of at least 3 ft from the edge of the roof.



Outdoor Lampholders

- they shall be attached only to conductors of the stranded type.

Vegetation as Support

- Vegetation such as trees shall not be used for support of overhead conductor spans.

More Than One Building or Other Structure

- **Number of Supplies**
  - a multiwire branch circuit shall be considered a single circuit.
- **Special Conditions**

(1) Fire pumps
(2) Emergency systems
(3) Legally required standby systems
(4) Optional standby systems
(5) Parallel power production systems
(6) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability

Disconnecting Means

- Means shall be provided for disconnecting all ungrounded conductors that supply or pass through the building or structure.

Location

- Install it at a readily accessible location (either outside or inside) nearest the point of entrance of the conductors .

Disconnect Construction

- Manually or Power Operable.
- Simultaneous Opening of Poles.
- Disconnection of Grounded Conductor.
- Indicating.

Rating of Disconnect

- **One-Circuit Installation.**
  - the branch circuit disconnecting means shall have a rating of not less than 15 amperes.
- **Two-Circuit Installations.**
  - the feeder or branch-circuit disconnecting means shall have a rating of not less than 30 amperes.
- **One-Family Dwelling.**
  - The feeder disconnecting means shall have a rating of not less than 100 amperes, 3-wire.
- **All Others.**
  - he feeder or branch-circuit disconnecting means shall have a rating of not less than 60 amperes.

Clearances over Roadways, Walkways,Rail, Water, and Open Land

Location	Clearance	
	m	ft
Open land subject to vehicles, cultivation, or grazing	5.6	18.5
Roadways, driveways, parking lots, and alleys	5.6	18.5
Walkways	4.1	13.5
Rails	8.1	26.5
Spaces and ways for pedestrians and restricted traffic	4.4	14.5
Water areas not suitable for boating	5.2	17.0

Clearances over Buildings and Other Structures

Clearance from Conductors or Live Parts from:	Horizontal		Vertical	
	m	ft	m	ft
Building walls, projections, and windows	2.3	7.5	—	—
Balconies, catwalks, and similar areas accessible to people	2.3	7.5	4.1	13.5
Over or under roofs or projections not readily accessible to people	—	—	3.8	12.5
Over roofs accessible to vehicles but not trucks	—	—	4.1	13.5
Over roofs accessible to trucks	—	—	5.6	18.5
Other structures	2.3	7.5	—	—

ARTICLE 2.30
SERVICES

Scope

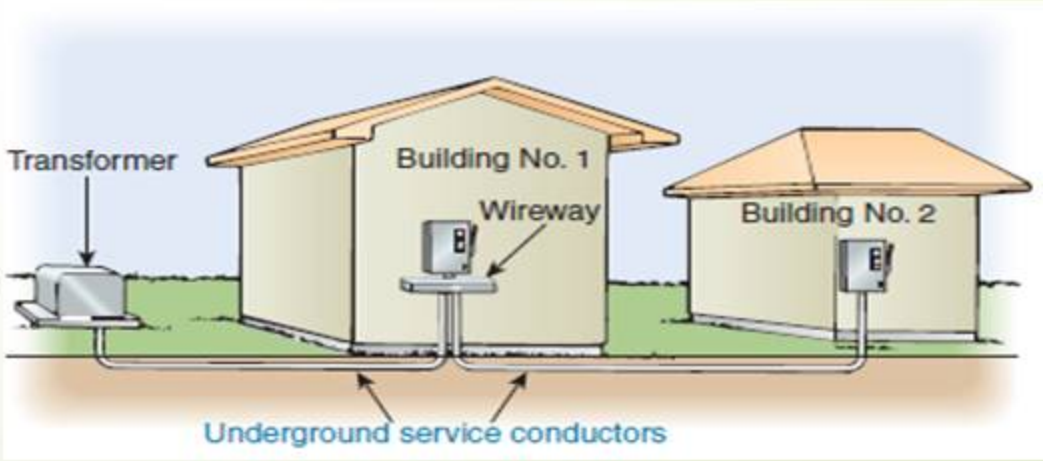
- This article covers service conductors and equipment for control and protection of services and their installation requirements.

A single-occupancy building with more than one service

One Building or Other Structure Not to Be Supplied Through Another

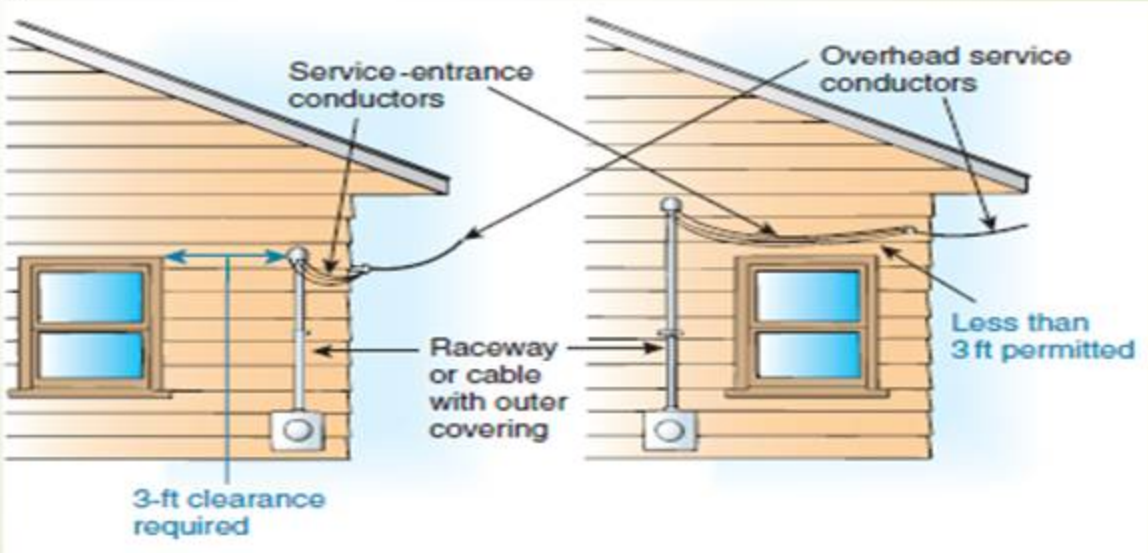
- Service conductors supplying a building or other structure shall not pass through the interior of another building or other structure.

  - *Service conductors installed not to pass through the interior of Building No. 1 to supply Building No. 2.*



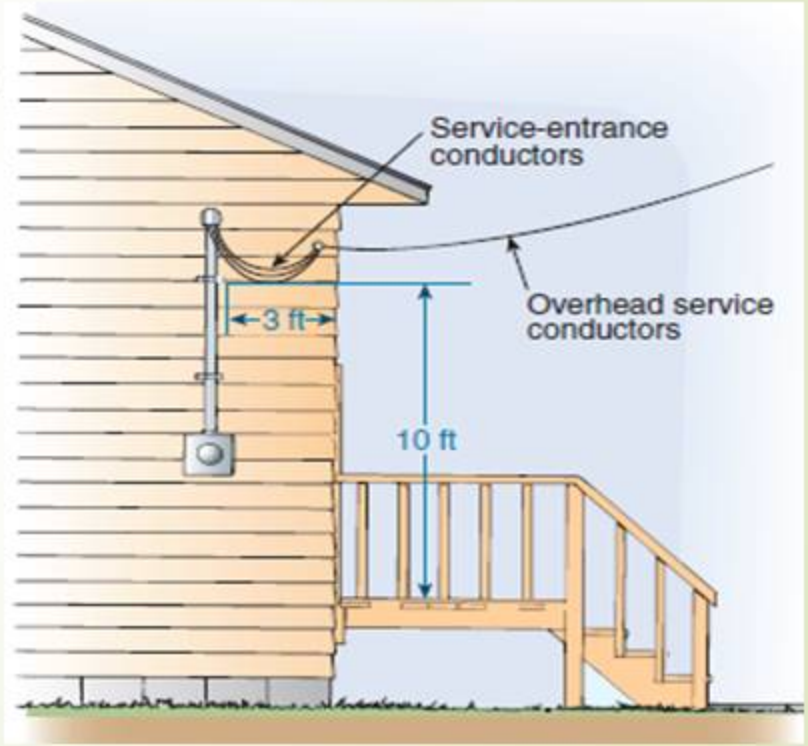
Clearances on Buildings

- **Clearances.**
  - Service conductors installed as open conductors or multiconductor cable without an overall outer jacket shall have a clearance of not less than 900 mm (3 ft) from windows



Clearances on Buildings

- **Vertical Clearance.**
  - The vertical clearance of final spans above, or within 900 mm (3 ft) measured horizontally of, platforms, projections, or surfaces from which they might be reached shall be maintained in accordance with 2.30.2.3(B).



Clearances on Buildings

- **Building Openings.**
  - Overhead service conductors shall not be installed beneath openings through which materials may be moved.

Vegetation as Support

- Vegetation such as trees shall not be used for support of overhead service conductors.

Overhead Service Conductors

- **Insulation or Covering**
  - Individual conductors shall be insulated or covered.
  - *Exception: The grounded conductor of a multiconductor cable shall be permitted to be bare.*
- **Size and Rating**
  - Conductors shall have sufficient ampacity to carry the current for the load and shall have adequate mechanical strength.

Underground Service Conductors

- *Exception: A grounded conductor shall be permitted to be uninsulated as follows:*
  - Bare copper used in a raceway.
  - Bare copper for direct burial where bare copper is judged to be suitable for the soil conditions.
  - Bare copper for direct burial without regard to soil conditions
  - Aluminum or copper-clad aluminum without individual insulation or covering use in a raceway or for direct burial.

Service-Entrance Conductors

- **Cable Trays.**
  - Cable tray systems shall be permitted to support service entrance conductors.
- **Drip Loops.**
  - Drip loops shall be formed on individual conductors to prevent the entrance of moisture.

Service Equipment — General

- **Enclosed.**
  - Energized parts shall be enclosed so that they will not be exposed to accidental contact or shall be guarded.
- **Guarded.**
  - Energized parts that are not enclosed shall be installed on a switchboard, panelboard, or control board and guarded.

Service Equipment - Disconnecting Means

- **Location.**
  - **Readily Accessible Location.**
    - either outside of a building or structure or inside nearest the point of entrance of the service conductors.
  - **Bathrooms.**
    - Service disconnecting means shall not be installed in bathrooms.
  - **Remote Control.**
    - Where a remote control device(s) is used to actuate the service disconnecting means

Service Equipment - Disconnecting Means

- **Marking.**
  - Each service disconnect shall be permanently marked to identify it as a service disconnect.
- **Suitable for Use.**
  - Each service disconnecting means shall be suitable for the prevailing conditions.

Maximum Number of Disconnects

- shall consist of not more than six switches or sets of circuit breakers mounted in a single enclosure.
  - Power monitoring equipment
  - Surge-protective device(s)
  - Control circuit of the ground-fault protection system
  - Power-operable service disconnecting means

Service Equipment — Overcurrent Protection

- Each ungrounded service conductor shall have overload protection.
- **Ungrounded Conductor.**
  - A set of fuses shall be considered all the fuses required to protect all the ungrounded conductors of a circuit.
- **Location**
  - The service over current device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto.

Service Equipment — Overcurrent Protection

- **Locked Service Over current Devices**
  - service overcurrent devices are locked or sealed or are not readily accessible and shall be of lower ampere rating than the service overcurrent device.
- **Protection of Specific Circuits**
  - an automatic overcurrent device that protects service conductors supplying only a specific load.

Service Equipment — Overcurrent Protection

- **Ground-Fault Protection of Equipment**
  - provided for solidly grounded wye electric services of more than 150 volts to ground but not exceeding 600 volts.
  - **Setting.**
    - The maximum setting of the ground-fault protection shall be 1200 amperes.
  - **Fuses.**
    - fuses employed shall be capable of interrupting any current higher than the interrupting capacity of the switch.

Services Exceeding 600 Volts, Nominal

- **Service-Entrance Conductors**
  - **Conductor Size.**
    - Service-entrance conductors shall not be smaller than 14 mm^2 unless in multi-conductor cable. Multiconductor cable shall not be smaller than 8.0 mm^2 (3.2 dia.).
- **Protection Requirements**
  - The protective device shall be capable of detecting and interrupting all values of current, in excess of its trip setting or melting point, that can occur at its location.

Metal-Enclosed Switchgear

- consist of a substantial metal structure and a sheet metal enclosure where installed over a combustible floor.

ARTICLE 2.40
OVERCURRENT PROTECTION

Scope

- This article provide the general requirements for overcurrent protection and overcurrent protective devices not more than 600 volts and for more than 600 volts, nominal.
- provided to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation.

Definitions

- **Current-Limiting Overcurrent Protective Device.**
  - reduces the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit.
- **Tap Conductors.**
  - has overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors that are protected as described in **Protection of Conductors.**

Protection of Conductors

- **Power Loss Hazard.**
  - Conductor overload protection shall not be required where the interruption of the circuit would create a hazard, such as in a material-handling magnet circuit.
- **Small Conductors.**
  - 15 amperes for 2.0 mm^2 (1.6 mm dia.),
  - 20 amperes for 3.5 mm^2 (2.0 mm dia.), and
  - 30 amperes for 5.5 mm^2 (2.6 mm dia.) copper

Protection of Conductors

- **Small Conductors.**
  - 15 amperes for 3.5 mm2 (2.0 mm dia.)
  - 25 amperes for 5.5 mm2 (2.6 mm dia.) for aluminum and copper-clad aluminum.
- **Tap Conductors.**
  - 2.10.2.1(a)(3) and (a)(4) **Household Ranges and Cooking Appliances and Other Loads**
  - 2.40.1.5(b)(2) **Fixture Wire**
  - 2.40.2.2 **Location in Circuit**
  - 3.68.2.8(b) **Reduction in Ampacity Size of Busway**
  - 3.68.2.8(c) **Feeder or Branch Circuits (busway taps)**
  - 4.30.4.3(d) **Single Motor Taps**

Protection of Flexible Cords, Flexible Cables, and Fixture Wires

- **Ampacities.**
- **Branch Circuit Overcurrent Device.**
  - Supply Cord of Listed Appliance or Portable Lamps.
  - Fixture Wire.
  - Extension Cord Sets.
  - Field Assembled Extension Cord Sets.

Standard Ampere Ratings

- **Fuses and Fixed-Trip Circuit Breakers.**
  - 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000 amperes.
- **Restricted Access Adjustable-Trip Circuit Breakers.**
  - Removable and sealable covers over the adjusting means
  - Bolted equipment enclosure doors
  - Locked doors accessible only to qualified personnel

Adjustable-Trip Circuit Breakers

Fuses or Circuit Breakers in Parallel

- shall be permitted to be connected in parallel where they are factory assembled in parallel and listed as a unit.

Thermal Devices

- permitted to protect motor branch-circuit conductors from overload if protected in accordance with 4.30.3.10. (**Overload Relays.)**

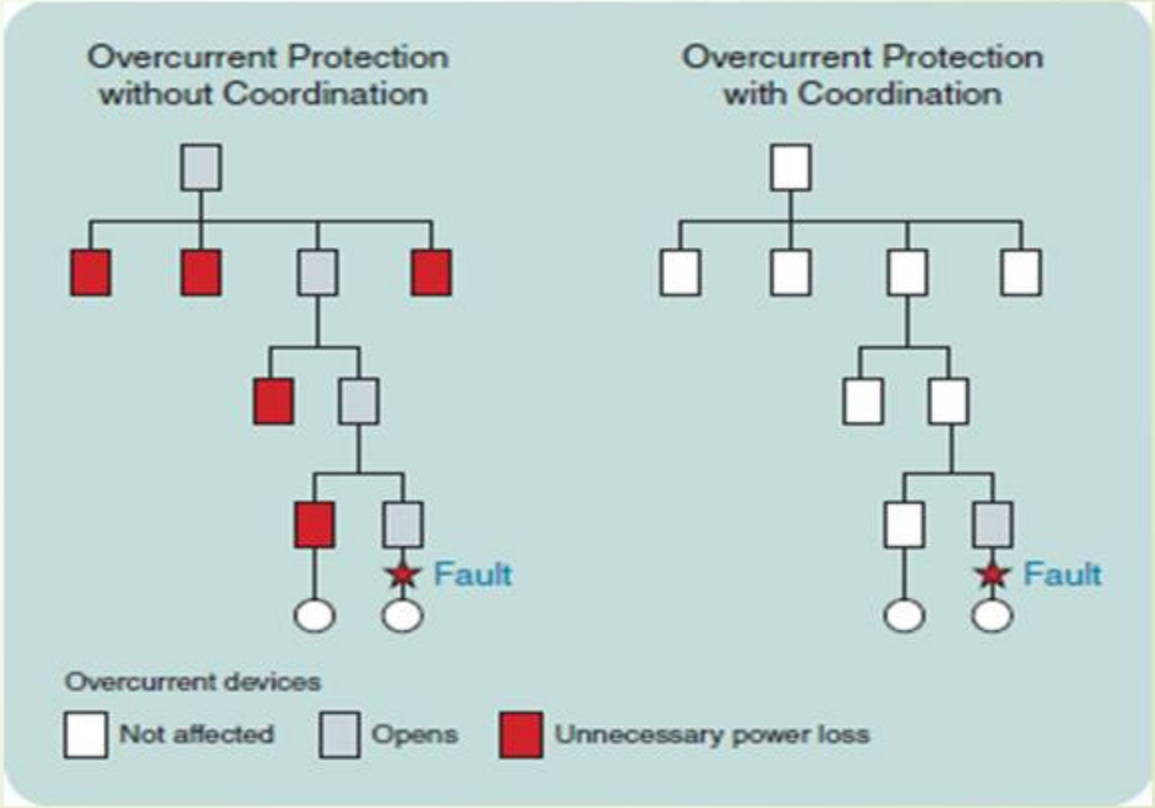
Supplementary Overcurrent Protection

- used for luminaires (lighting fixtures), appliances, and other equipment or for internal circuits and components of equipment.

Electrical System Coordination

- Where an orderly shutdown is required to minimize the hazard(s) to personnel and equipment.

Electrical System Coordination

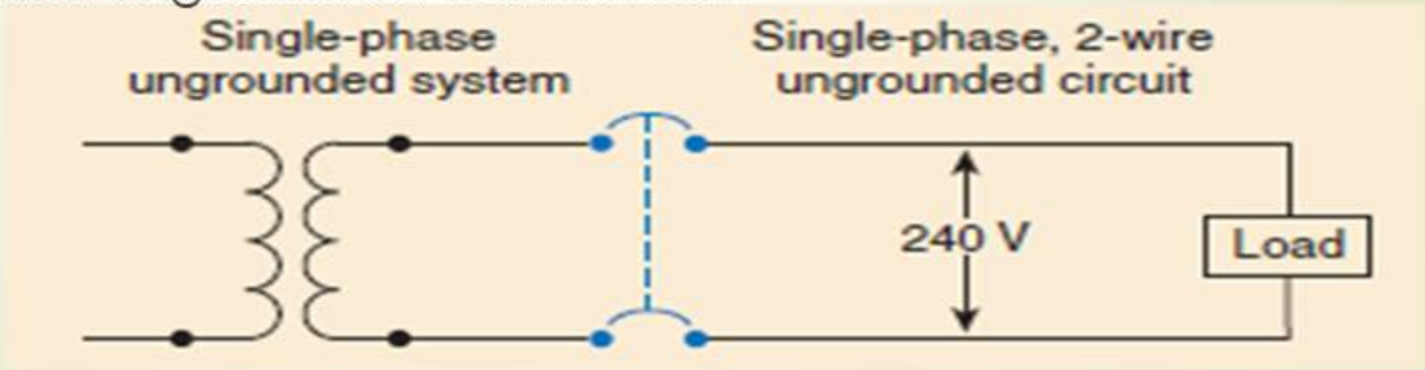


Ungrounded Conductors

- **Overcurrent Device Required.**
  - A fuse or an overcurrent trip unit of a circuit breaker shall be connected in series with each ungrounded conductor.
- **Circuit Breaker as Overcurrent Device.**
  - Multiwire Branch Circuit.
    - permitted as the protection for each ungrounded conductor of multiwire branch circuits that serve only single-phase line-to-neutral loads.

Ungrounded Conductors

- **Circuit Breaker as Overcurrent Device.**
  - Grounded Single-Phase and 3-Wire dc Circuits.
    - individual single-pole circuit breakers with identified handle ties shall be permitted as the protection for each ungrounded conductor.



Ungrounded Conductors

- **Closed-Loop Power Distribution Systems.**
  - Listed devices that provide equivalent overcurrent protection in closed-loop power distribution systems shall be permitted as a substitute for fuses or circuit breakers.

Change in Size of Grounded Conductor

- similar change shall be permitted to be made in the size of the grounded conductor because of voltage drop problems.

Location in or on Premises

- Accessibility.
- Occupancy.
- Not Exposed to Physical Damage.
- Not in Vicinity of Easily Ignitible Material.
- Not Located in Bathrooms.
- Not Located over Steps.

Enclosures

- **Protection from Physical Damage.**
  - Installation in enclosures, cabinets, cutout boxes, or equipment assemblies.
  - Mounting on open-type switchboards, panelboards, or control boards that are in rooms or enclosures free from dampness and easily ignitible material and are accessible only to qualified personnel.
- **Operating Handle.**
  - The operating handle of a circuit breaker shall be permitted to be accessible without opening a door or cover.

Disconnecting and Guarding

- **Disconnecting Means for Fuses.**
  - each circuit containing fuses can be independently disconnected from the source of power.
- **Arcing or Suddenly Moving Parts.**
  - **Location.** Fuses and circuit breakers shall be located or shielded so that persons will not be burned or otherwise injured by their operation.
  - **Suddenly Moving Parts.** Handles or levers of circuit breakers, and similar parts that may move suddenly in such a way that persons in the vicinity are likely to be injured by being struck by them, shall be guarded or isolated.

Plug Fuses, Fuseholders, and Adapters

- **Maximum Voltage.**
  - Circuits not exceeding 125 volts between conductors
  - Circuits supplied by a system having a grounded neutral point where the line-to-neutral voltage does not exceed 150 volts
- **Marking.**
  - Each fuse, fuseholder, and adapter shall be marked with its ampere rating.

Plug Fuses, Fuseholders, and Adapters

- **Hexagonal Configuration.**
  - Plug fuses of 15-ampere and lower rating shall be identified by a hexagonal configuration of the window, cap, or other prominent part to distinguish them from fuses of higher ampere ratings.

Plug Fuses, Fuseholders, and Adapters

- **No Energized Parts.**
  - Plug fuses, fuseholders, and adapters shall have no exposed energized parts after fuses or fuses and adapters have been installed.
- **Screw Shell.**
  - The screw shell of a plug-type fuseholder shall be connected to the load side of the circuit.

Edison-Base Fuses

- **Classification.**
  - Plug fuses of the Edison-base type shall be classified at not over 125 volts and 30 amperes and below.
- **Replacement Only.**
  - Plug fuses of the Edison-base type shall be used only for replacements in existing installations where there is no evidence of overfusing or tampering.

Edison-Base Fuses

- **Edison-Base Fuseholders.**
  - Fuseholders of the Edison-base type shall be installed only where they are made to accept Type S fuses by the use of adapters.
- **Type S Fuses**
  - **Classification.** Type S fuses shall be classified at not over 125 volts and 0 to 15 amperes, 16 to 20 amperes, and 21 to 30 amperes.

Type S Fuses

- **Non-interchangeable.** They shall be designed so that they cannot be used in any fuseholder other than a Type S fuseholder or a fuseholder with a Type S adapter inserted with a lower ampere classification.

Type S Fuses, Adapters, and Fuseholders

- **To Fit Edison-Base Fuseholders.**
  - Type S adapters shall fit Edison-base fuseholders.
- **To Fit Type S Fuses Only.**
  - Type S fuseholders and adapters shall be designed so that either the fuseholder itself or the fuseholder with a Type S adapter inserted cannot be used for any fuse other than a Type S fuse.
- **Nonremovable.**
  - Type S adapters shall be designed so that once inserted in a fuseholder, they cannot be removed.

Type S Fuses, Adapters, and Fuseholders

- **Non-tamperable**.
  - Type S fuses, fuseholders, and adapters shall be designed so that tampering or shunting (bridging) would be difficult.
- **Interchangeability**.
  - Dimensions of Type S fuses, fuseholders, and adapters shall be standardized to permit interchangeability regardless of the manufacturer.

Cartridge Fuses and Fuseholders

- **Maximum Voltage — 300-Volt Type.**
  - Cartridge fuses and fuseholders of the 300-volt type shall be permitted to be used in the following circuits:
    - Circuits not exceeding 300 volts between conductors
    - Single-phase line-to-neutral circuits supplied from a 3-phase, 4-wire, solidly grounded neutral source where the line-to-neutral voltage does not exceed 300 volts

Cartridge Fuses and Fuseholders

- **Noninterchangeable — 0–6000-Ampere Cartridge Fuseholders.**
  - Fuseholders for current-limiting fuses shall not permit insertion of fuses that are not current-limiting.
- **Marking.**
  - Ampere rating
  - Voltage rating
  - Interrupting rating where other than 10,000 amperes
  - Current limiting where applicable
  - The name or trademark of the manufacturer

Circuit Breakers

- **Method of Operation.**
  - Circuit breakers shall be trip free and capable of being closed and opened by manual operation.
- **Indicating.**
  - Circuit breakers shall clearly indicate whether they are in the open "off" or closed "on" position.
- **Nontamperable.**
  - A circuit breaker shall be of such design that any alteration of its trip point (calibration) or the time required for its operation requires dismantling of the device or breaking of a seal for other than intended adjustments.

Circuit Breakers

- **Marking.**
  - **Durable and Visible**. Circuit breakers shall be marked with their ampere rating in a manner that will be durable and visible after installation.
  - **Location**. Circuit breakers rated at 100 amperes or less and 600 volts or less shall have the ampere rating molded, stamped, etched, or similarly marked into their handles or escutcheon areas.

Circuit Breakers

- **Marking.**
  - **Interrupting Rating.** other than 5000 amperes shall have its interrupting rating shown on the circuit breaker.
  - **Used as Switches.** in 120-volt and 277-volt fluorescent lighting circuits shall be listed and shall be marked SWD or HID.
  - **Voltage Marking.** shall be marked with a voltage rating not less than the nominal system voltage that is indicative of their capability to interrupt fault currents between phases or phase to ground.

Supervised Industrial Installations

- used exclusively for manufacturing or process control activities.
- **Location in Circuit.**
  - **Feeder and Branch-Circuit Conductors.**
    - Feeder and branch-circuit conductors shall be protected at the point the conductors receive their supply as permitted in 240.21 **(overcurrent protection for conductors).**

Supervised Industrial Installations

- **Transformer Secondary Conductors of Separately Derived Systems.**
  - Short-Circuit and Ground-Fault Protection.
    - The length of the secondary conductors does not exceed 30 m and the transformer primary overcurrent device has a rating or setting that does not exceed 150 percent of the value determined by multiplying the secondary conductor ampacity by the secondary-to primary transformer voltage ratio.
    - The conductors are protected by a differential relay with a trip setting equal to or less than the conductor ampacity.

Supervised Industrial Installations

- **Transformer Secondary Conductors of Separately Derived Systems.**
  - Overload Protection.
    - The conductors terminate in a single overcurrent device that will limit the load to the conductor ampacity.
    - There shall be no more than six overcurrent devices grouped in any one location.
    - Overcurrent relaying is connected [with a current transformer(s), if needed] to sense all of the secondary conductor current and limit the load to the conductor ampacity by opening upstream or downstream devices.

Supervised Industrial Installations

- **Outside Feeder Taps.**
  - The conductors are protected from physical damage in an approved manner.
  - The tap conductors are installed outdoors of a building or structure except at the point of load termination.
  - The overcurrent device for the conductors is an integral part of a disconnecting means or shall be located immediately adjacent thereto.

Supervised Industrial Installations

- **Protection by Primary Overcurrent Device.**
  - Conductors supplied by the secondary side of a transformer shall be permitted to be protected by overcurrent protection provided on the primary (supply) side of the transformer.

Supervised Industrial Installations

- **Series Ratings.** the circuit breaker shall meet the requirements specified:
  - **Tested Combinations.** The combination of line-side overcurrent device and load-side circuit breaker(s) is tested and marked on the end use equipment, such as switchboards and panelboards.
  - **Selected Under Engineering Supervision.** The line-side device is selected including identification of the upstream device, shall be field marked on the end use equipment.

Supervised Industrial Installations

- **Motor Contribution.** Series ratings shall not be used where:
  - Motors are connected on the load side of the higher-rated overcurrent device and on the line side of the lower-rated overcurrent device.
  - The sum of the motor full-load currents exceeds 1 percent of the interrupting rating of the lower-rated circuit breaker.

Overcurrent Protection Over 600 Volts, Nominal

- **Feeders and Branch Circuits.**
  - **Overcurrent Relays and Current Transformers.** 3-phase circuits shall have a minimum of three overcurrent relay elements operated from three current transformers.
  - **Fuses.** A fuse shall be connected in series with each ungrounded conductor.

Overcurrent Protection Over 600 Volts, Nominal

- **Protective Devices.**
  - capable of detecting and interrupting all values of current that can occur at their location in excess of their trip-setting or melting point.
- **Conductor Protection.**
  - the conductor used shall be coordinated to prevent damaging or dangerous temperatures in conductors or conductor insulation under short-circuit conditions.

Overcurrent Protection Over 600 Volts, Nominal

- **Additional Requirements for Feeders.**
  - **Rating or Setting of Overcurrent Protective Devices.**
    - The continuous ampere rating of a fuse shall not exceed three times the ampacity of the conductors.
  - **Feeder Taps.**
    - Conductors tapped to a feeder shall be permitted to be protected by the feeder overcurrent device where that overcurrent device also protects the tap conductor.

GROUNDING AND BONDING

- DEFINITIONS

Supply-Side Bonding Jumper

-A conductor installed on the supply side of a service that ensures electrical conductivity between metal parts required to be electrically connected.

Effective Ground-Fault Current Path

-An intentionally constructed, low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions

Ground-Fault Current Path

-An electrically conductive path from the point of a ground fault on a wiring system through normally non–current-carrying conductors, equipment, or the earth to the electrical supply source.

GROUNDING AND BONDING

- Grounding is the intentional connection of a current carrying conductor to ground or something that serves in place of ground.
- Where a system operates "ungrounded" it does not have an intentionally grounded circuit conductor *(grounded conductor) but equipment grounding through the use of an equipment grounding conductor is required.*

GROUNDING AND BONDING

- There are two basic reasons for grounding:

1. To limit the voltages caused by lightning or by accidental contact of the supply conductors with conductors of higher voltage
2. To stabilize the voltage under normal operating conditions (which maintains the voltage at one level relative to ground, so that any equipment connected to the system will be subject only to that potential difference)

GROUNDING AND BONDING

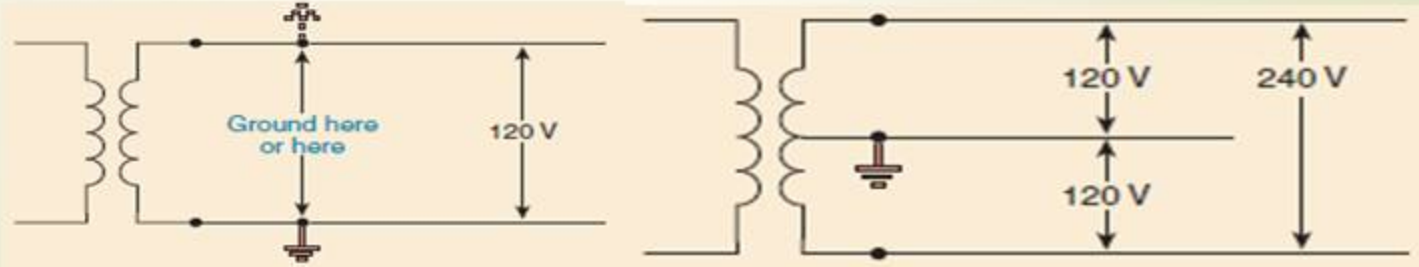
SYSTEM GROUNDING:

- **Alternating-Current Systems of Less Than 50 Volts**

  if the transformer supply system exceeds 150 volts to ground

- **Alternating-Current Systems of 50 Volts to 1000 Volts**

  1. the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts



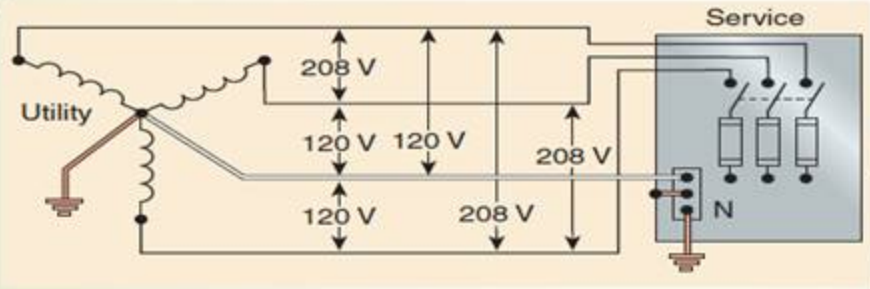
GROUNDING AND BONDING

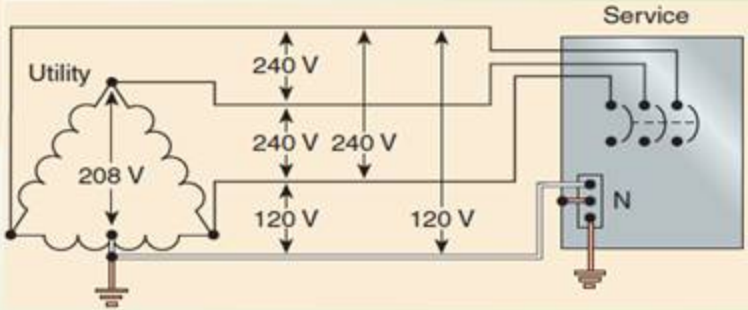
SYSTEM GROUNDING:

- **Alternating-Current Systems of 50 Volts to 1000 Volts**

2.) 3-phase, 4-wire, wye-the neutral conductor is used as a circuit conductor

3.) 3-phase, 4-wire, delta-the midpoint of one phase winding is used as a circuit conductor





GROUNDING AND BONDING

SYSTEM GROUNDING:

- **Alternating-Current Systems of 50 Volts to Less Than 1000 Volts Not Required to Be Grounded:**
  - ✓ Electrical systems used to supply industrial electric furnaces for melting, refining, tempering
  - ✓ for rectifiers that supply only adjustable-speed industrial drives
  - ✓ supplied by transformers that primary voltage rating less than 1000V
- **Ground Detectors**
  - ✓ The ground detection sensing equipment shall be connected as close as practicable to where the system receives its supply.

GROUNDING AND BONDING

SYSTEM GROUNDING:

- **Marking**

✓ Ungrounded systems shall be legibly marked "Ungrounded System" at the source or first disconnecting means

GROUNDING AND BONDING

SYSTEM GROUNDING:

- **Circuits Not to Be Grounded**

1) Circuits for electric cranes operating over combustible fibers

(2) Circuits in health care facilities

(3) Circuits for equipment within electrolytic cell working zone

(4) Secondary circuits of lighting systems

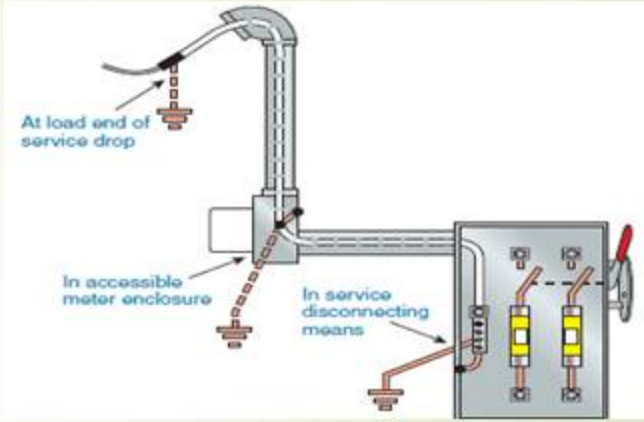
(5) Secondary circuits

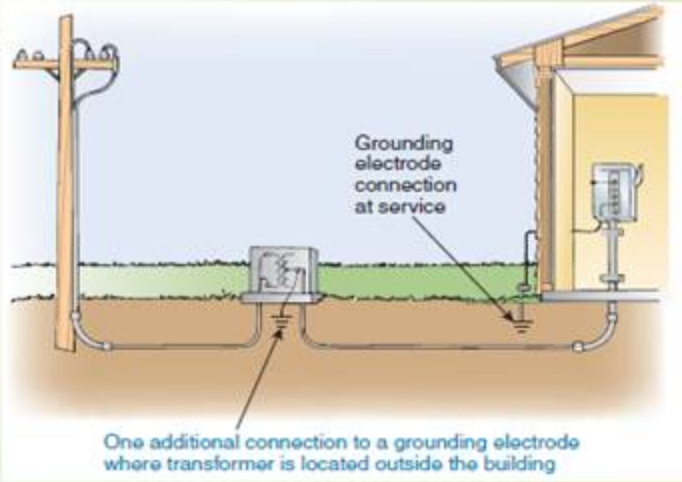
GROUNDING AND BONDING

SYSTEM GROUNDING:

- **Grounding Service-Supplied AC Systems**

1. **General** –connection shall be made at any accessible point from the load end of the service drop or service lateral to and including the terminal or bus.
2. **Outdoor Transformer** – at least one additional Grounding connection is to be made from the grounded Service conductor to the electrode
3. **Load-Side Grounding Connections-** reconnected to ground on the load side of the service disconnecting means except as otherwise permitted in this article.





GROUNDING AND BONDING

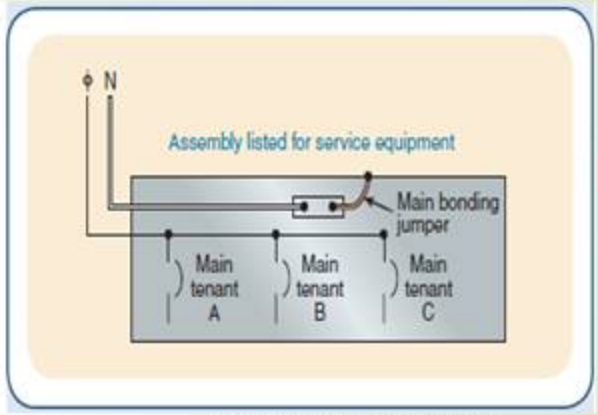
SYSTEM GROUNDING:

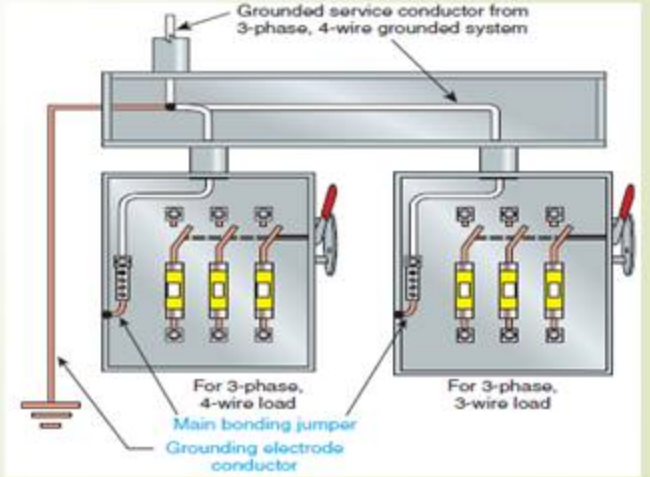
- **Grounded Conductor Brought to Service Equipment**

A main bonding jumper shall connect the grounded conductor(s) to each service disconnecting means enclosure.

Exception:

Where two or more service disconnecting means are located in a single assembly



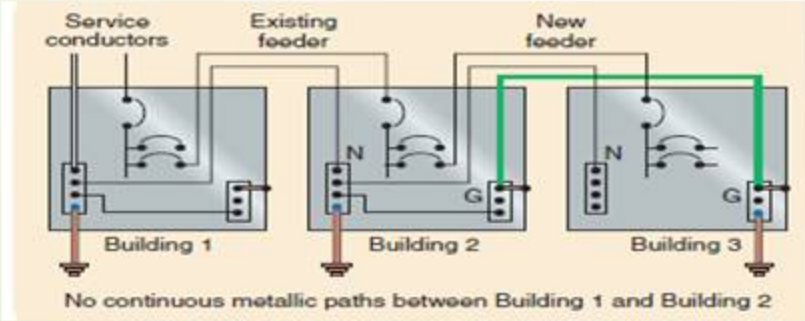


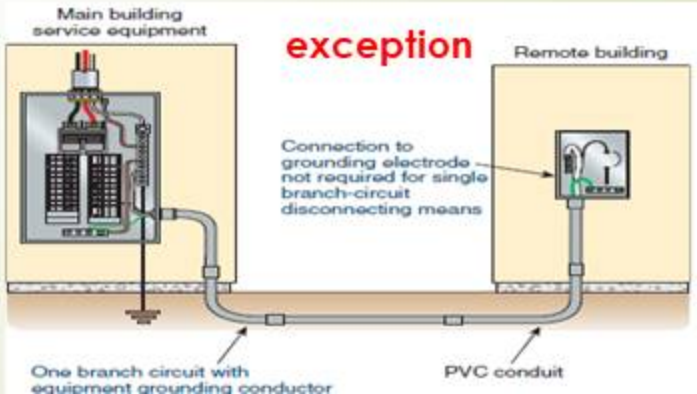
GROUNDING AND BONDING

SYSTEM GROUNDING:

- **Main Bonding Jumper and System Bonding Jumper**
  - ✓ Material - of copper or other corrosion-resistant material
  - ✓ Construction - main bonding jumper or a system bonding jumper is a screw only (green color)
  - ✓ Size
- **Buildings or Structures Supplied by a Feeder(s) or Branch Circuit(s)**

1. Grounding electrode - shall have a grounding electrode or grounding electrode system





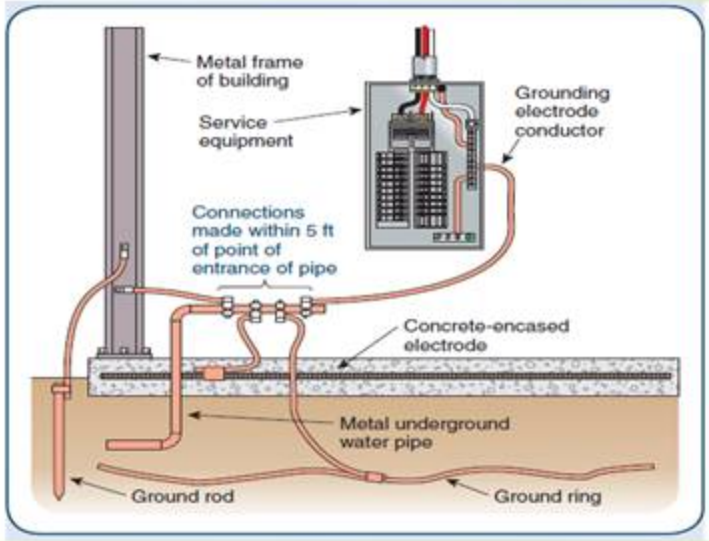
GROUNDING AND BONDING

GROUNDING ELECTRODE SYSTEM AND GROUNDING ELECTRODE CONDUCTOR:

- Grounding Electrode System - All grounding electrodes as described in that are present at each building or structure served shall be bonded together to form the grounding electrode system.

Exception:

Concrete-encased electrodes of existing buildings or structures shall not be required to be part of the grounding electrode system where the steel reinforcing bars or rods are not accessible for use without disturbing the concrete.



GROUNDING AND BONDING

GROUNDING ELECTRODE SYSTEM AND GROUNDING ELECTRODE CONDUCTOR:

- Electrodes Permitted for Grounding

1. **Metal Underground Water Pipe**

- ✓ direct contact with the earth for 3.0 m (10 ft) or more

2. **Metal Frame of the Building or Structure**

- ✓ At least one structural metal member that is in direct contact with the earth for 3.0 m (10 ft) or more

3. **Concrete-Encased Electrode**

- ✓ shall consist of at least 6.0 m (20 ft) bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than 13 mm (1/2 in.) in diameter, installed in one continuous 6.0 m (20 ft) length
- ✓ Bare copper conductor not smaller than 4 AWG

GROUNDING AND BONDING

GROUNDING ELECTRODE SYSTEM AND GROUNDING ELECTRODE CONDUCTOR:

- Electrodes Permitted for Grounding

4. **Ground Ring**

- ✓ of at least 6.0 m (20 ft) of bare copper conductor not smaller than 2 AWG.

5. **Rod and Pipe Electrodes**

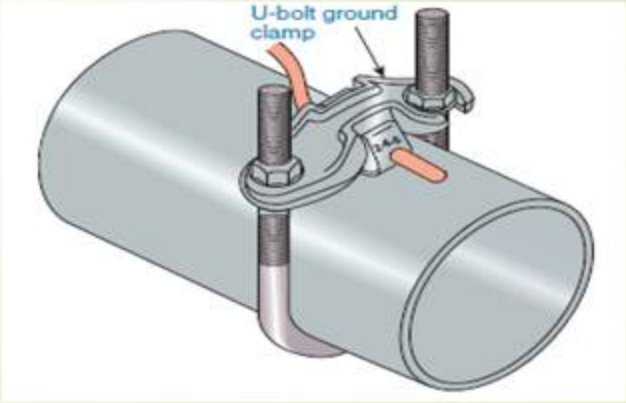
- ✓ shall not be less than 2.44 m (8 ft) in length and shall consist of the following materials.
  - (a) shall not be smaller than 21 (trade size 3⁄4)
  - (b) of stainless steel and copper or zinc coated steel shall be at least 15.87 mm (5⁄8 in.) in diameter

6. **Plate Electrodes**

- ✓ Each plate electrode shall expose not less than 0.186 m2 (2 ft2) of surface to exterior soil.

GROUNDING AND BONDING

- Not Permitted for Use as Grounding Electrodes
  - ✓ metal underground gas piping system
  - ✓ Aluminum
- Methods of Grounding and Bonding Conductor Connection to Electrodes
  - ✓ shall be connected to the grounding electrode by exothermic welding, listed lugs, listed pressure connectors, listed clamps, or other listed means.



GROUNDING AND BONDING

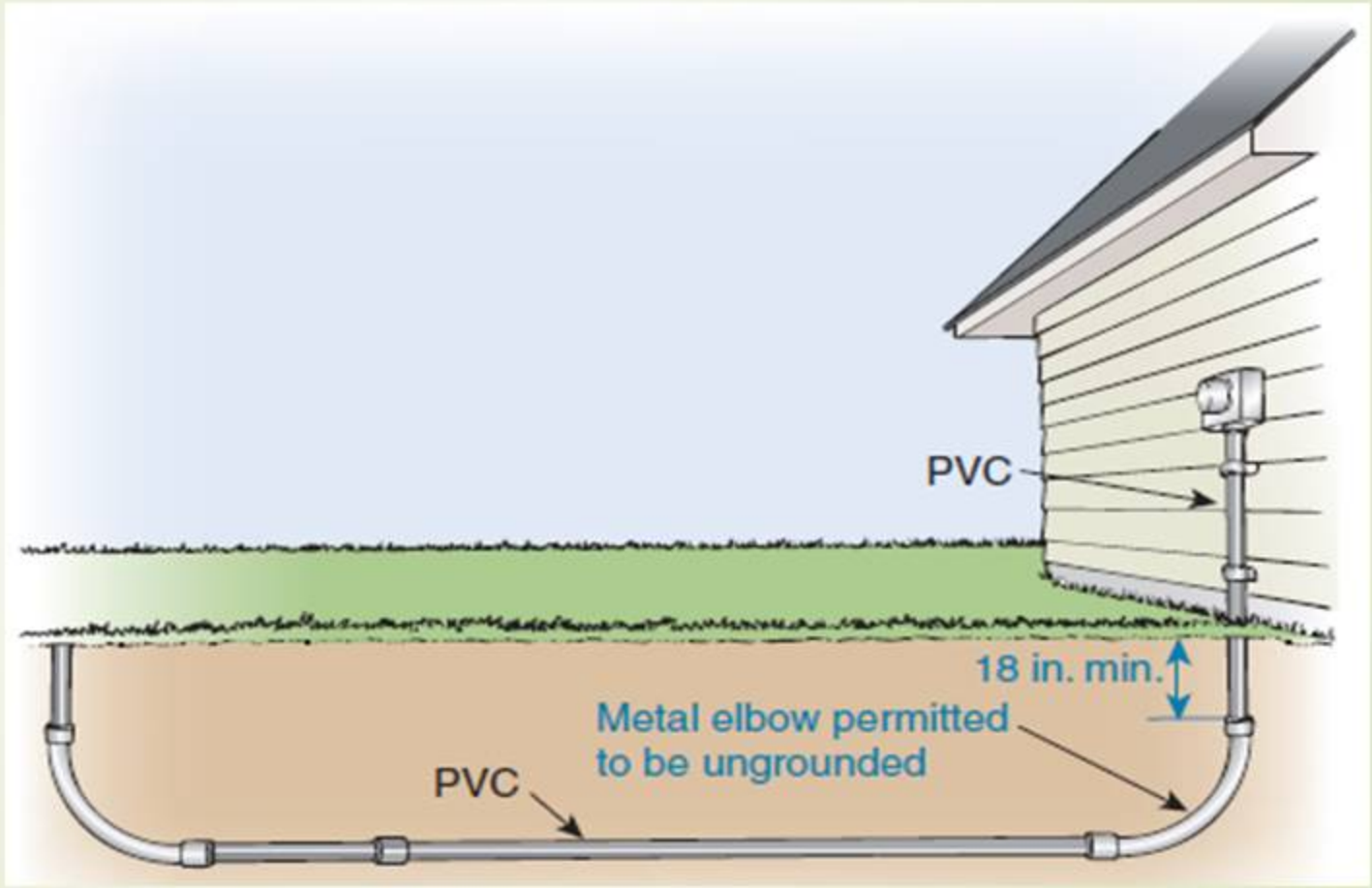
ENCLOSURE , RACEWAY, & SERVICE CABLE CONNECTION:

- **Service Raceways and Enclosures**

✓ Metal enclosures and raceways for service conductors and equipment shall be connected to the grounded system conductor

Exception:

A metal elbow that is installed in an underground nonmetallic raceway and is isolated from possible contact by a minimum cover of 450 mm (18 in.) to any part of the elbow shall not be required to be connected to the grounded system conductor or grounding electrode conductor

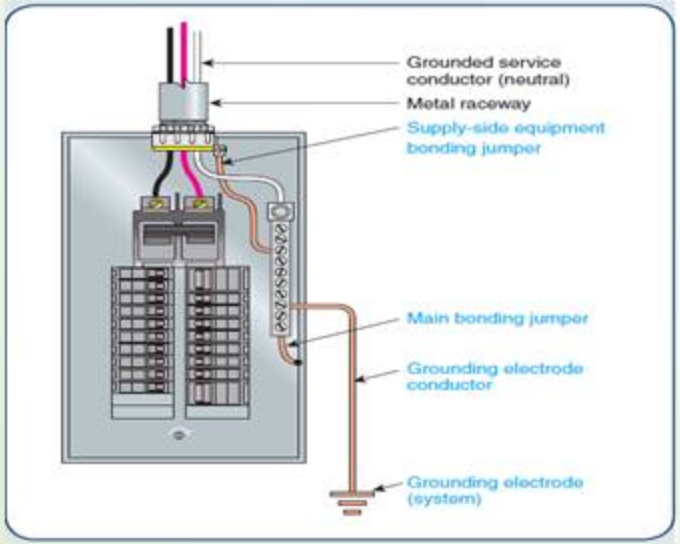

PVC
18 in. min.
Metal elbow permitted
to be ungrounded
PVC

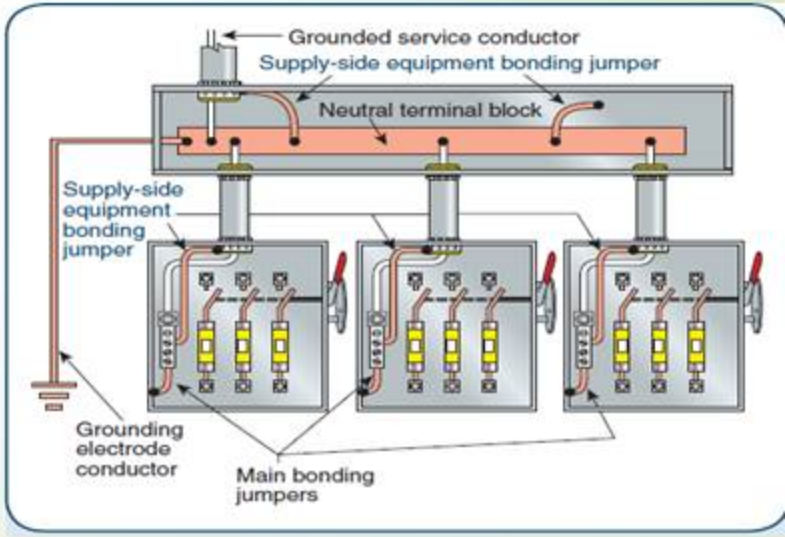
GROUNDING AND BONDING

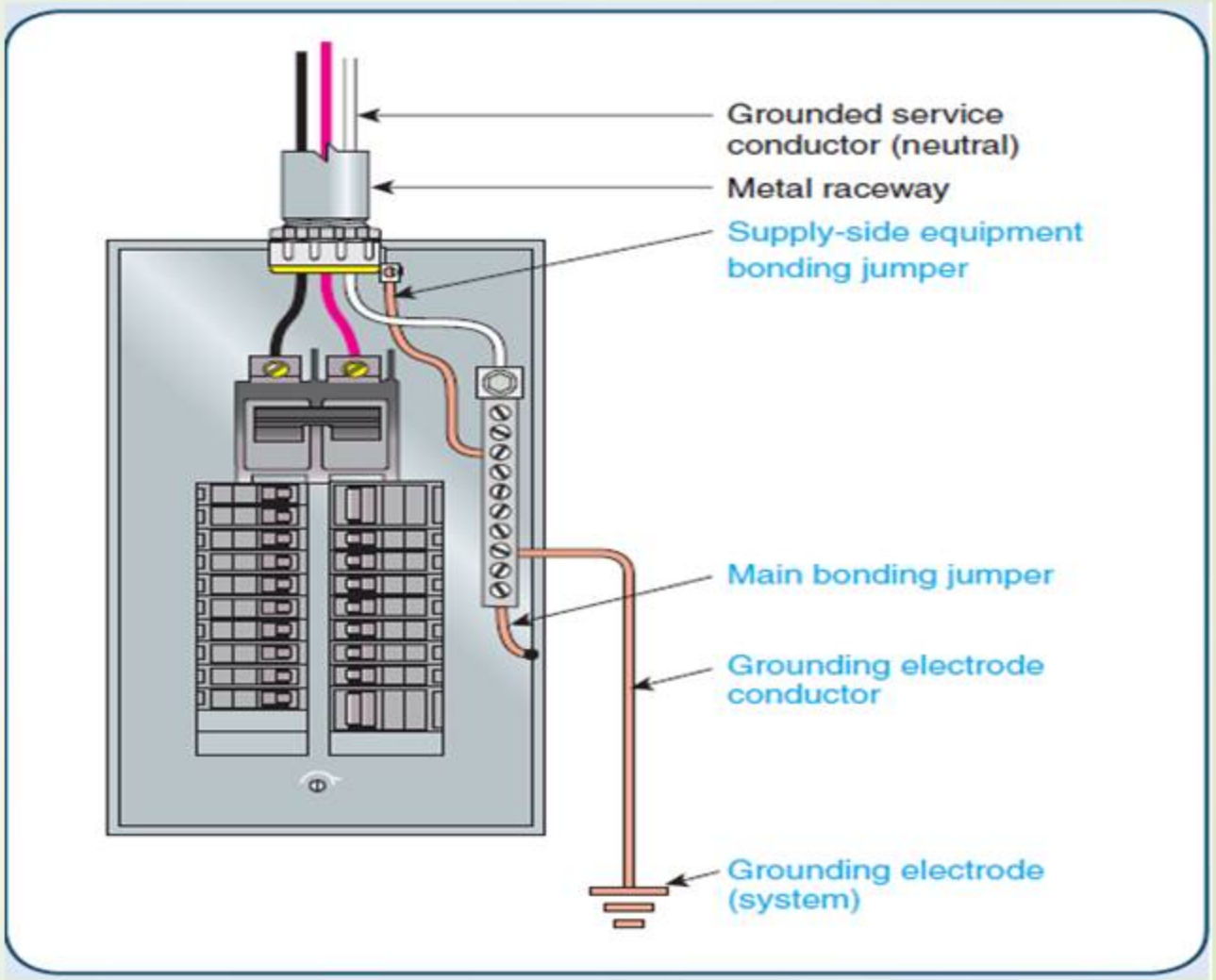
BONDING:

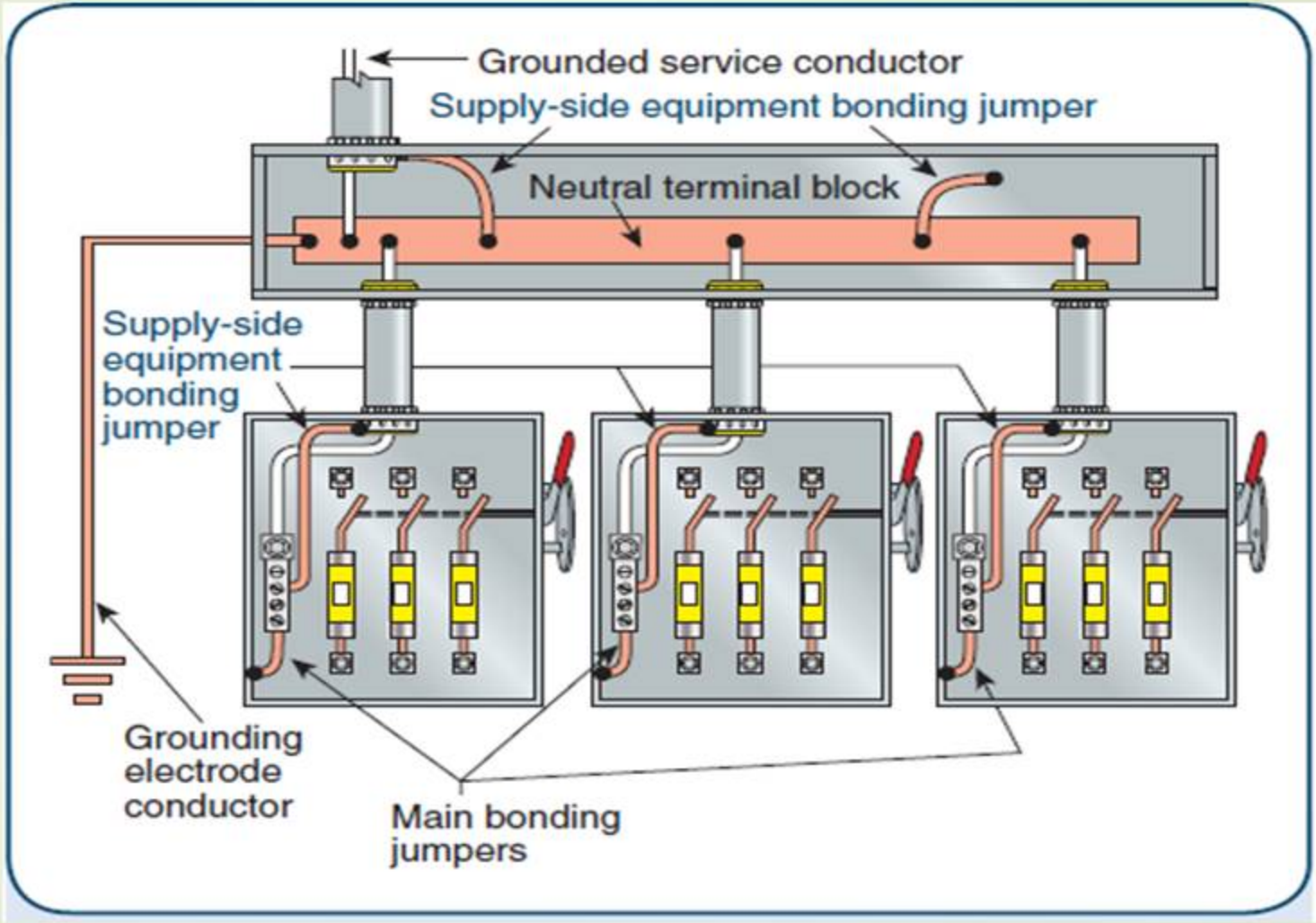
- Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

- **Method of Bonding at the Service**






Grounded service conductor (neutral)
Metal raceway
Supply-side equipment bonding jumper
Main bonding jumper
Grounding electrode conductor
Grounding electrode (system)


Grounded service conductor
Supply-side equipment bonding jumper
Neutral terminal block
Supply-side equipment bonding jumper
Grounding electrode conductor
Main bonding jumpers

GROUNDING AND BONDING

BONDING:

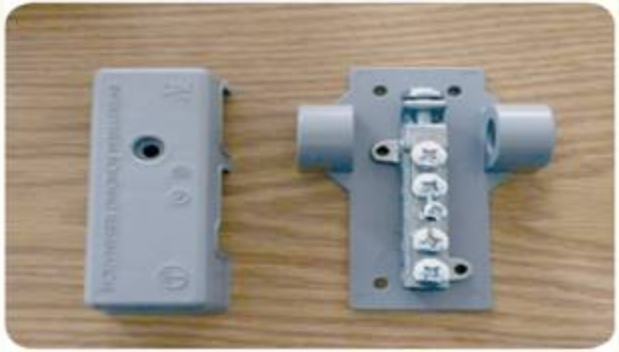
- **Method of Bonding at the Service**

GROUNDING AND BONDING

BONDING:

- BONDING OTHER SYSTEMS

grounding wedge lug



listed intersystem bonding termination

Note: Connections depending solely on solder shall not be used.

listed

GROUNDING AND BONDING

BONDING:

- BONDING OTHER SYSTEMS

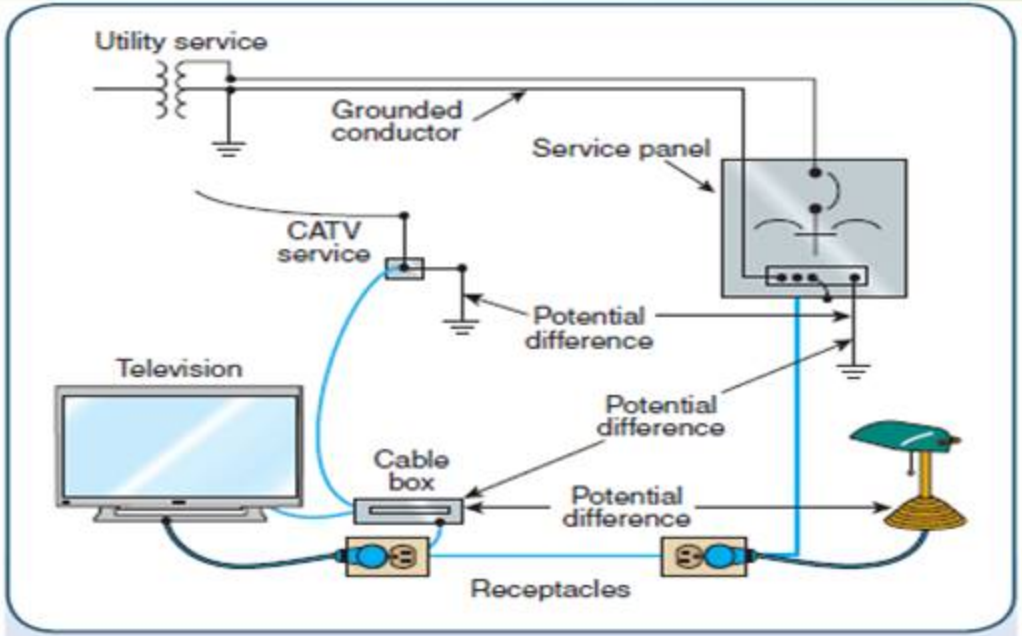


EXHIBIT 250.43 *A CATV installation that does not comply with the Code, illustrating why bonding between different systems is necessary.*

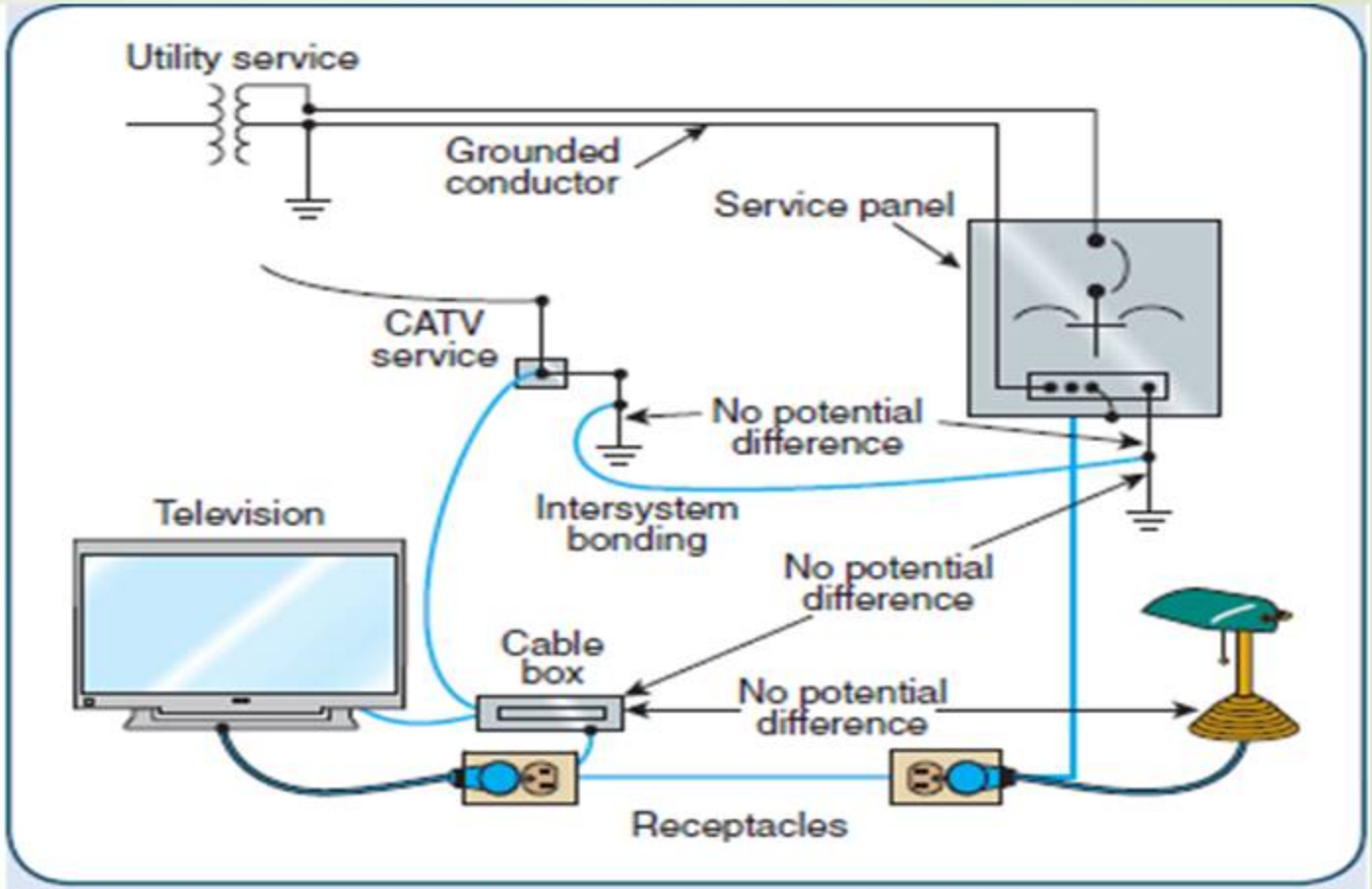


EXHIBIT 250.44 *A cable TV installation that complies with 250.94.*

GROUNDING AND BONDING

Equipment Grounding and Equipment Grounding Conductors:

- Equipment Connected by Cord and Plug
- ✓ normally non–current-carrying metal parts of cord-and-plug-connected equipment shall be connected to the equipment grounding conductor.

In residential occupancies:

a. Refrigerators, freezers, and air conditioners

b. Clothes-washing, clothes-drying, dish-washing machines; ranges; kitchen waste disposers; information technology equipment; sump pumps and electrical aquarium equipment

c. Hand-held motor-operated tools, stationary and fixed motor-operated tools, and light industrial motor operated tools

d. Motor-operated appliances of the following types: hedge clippers, lawn mowers, snow blowers, and wet scrubbers

e. Portable handlamps

GROUNDING AND BONDING

Methods of Equipment Grounding:

- Equipment Grounding Conductor Connections

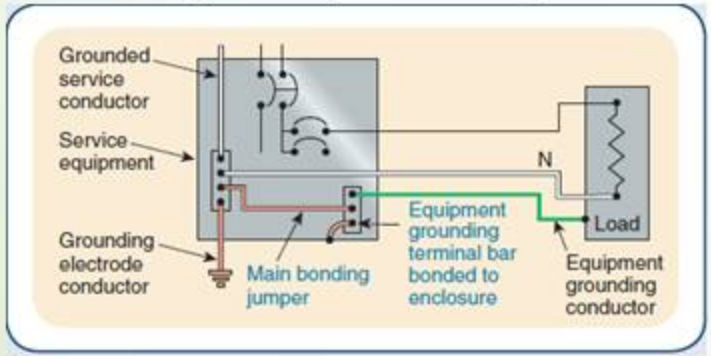
1. For Grounded Systems

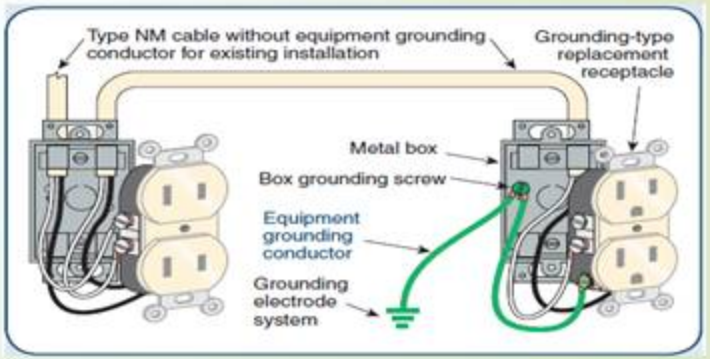
- ✓ bonding the equipment grounding conductor to the Grounded service conductor and the grounding electrode conductor.

2. **For Ungrounded Systems**

- ✓ The connection shall be made by bonding the equipment grounding conductor to the grounding electrode conductor.

3. **Non-grounding Receptacle Replacement or Branch Circuit Extensions.**





GROUNDING AND BONDING

Methods of Equipment Grounding:

- **Connecting Receptacle Grounding Terminal to Box**
  1. Surface-Mounted Box - direct metal-to-metal contact
  2. Contact Devices or Yokes -supporting screws to establish the grounding circuit
  3. Floor Boxes
  4. Isolated Receptacles

GROUNDING AND BONDING

Instruments, Meters, and Relays:

- **Instrument Transformer Circuits**

  Secondary circuits of current and potential instrument transformers shall be grounded where the primary windings are connected to circuits of 300 volts or more to ground and shall be grounded irrespective of voltage.

Exception No. 1: Circuits where the primary windings are connected to circuits of less than 1000 volts with no live parts or wiring exposed or accessible to other than qualified persons.

Exception No. 2: Current transformer secondaries connected in a three-phase delta configuration shall not be required to be grounded.

SURGE ARRESTERS, OVER 1000 VOLTS

Qualifications:

A. <u>Rating</u>

- The rating of a surge arrester shall be equal to or greater than the maximum continuous operating voltage at the point of application.

B. <u>Silicon Carbide Types</u>

-The rating of a silicon carbide type surge arrester shall be not less than 125% of rating specified in A.

Installation:

- Location
- Uses Not Permitted
- Routing of Surge Arrester Grounding Conductors

Connection:

1. Grounded service conductors
2. Grounding electrode conductors
3. Grounding electrode for the service
4. Equipment grounding terminal in the service equipment

Surge-Arrester Conductors

The conductor between the surge arrester and the line and surge arrester and the grounding connection shall not be smaller than 14mm copper or alluminum.

Interconnections:

A. Metal Interconnection

1. Additional Grounding Connection
2. Multigrounded Neutral System Connection

B. Through Spark Gap or Device

1. Ungrounded or Unigrounded Primary system
2. Multigrounded Neutral Primary System.

SURGE-PROTECTIVE DEVICES (SPDs), 1000 VOLTS OR LESS

Scope:

Is to discussed the general requirements such us: Installation requirements, and connection requirements for surge-protective devices (SPDs) permanently installed on premises wiring system of 1000 volts or less.

What is SPDS?

SPDs are design to protect against transient surge conditions, such as lightning.

Installation of SPDs

Location

SPDs shall be located indoors and outdoors and shall be made inaccessible to unqualified person.

Routing of Connection

The conductors used shall connect the SPD to the line or bus and to the ground shall not be any longer than necessary and shall avoid unnecessary bends.

Connecting SPDs

Type 1

Shall be connected to the supply side and it should be connected at least one of the following:

- Grounded service conductor
- Grounding electrode conductor
- Grounding electrode for the service

Types 2 SPDs

- Is the main protection system for all low voltage electrical installations.
- Installed in each electrical switch board, it prevents the spread of over-voltages in the electrical installations and protects the loads.

Type 3 SPDs

- Shall be installed on the load side of branch-circuit overcurrent protection up to the equipment serve.
- These SPDs has a low discharge capacity and mandatorily be installed as supplement for type 2.

PROTECTION AGAINST LIGHTNING

Lightning Protection System

-is a complete system of terminals, conductors, ground terminals, interconnecting conductors, arresters and other connectors or fittings required to complete the system.

Air Terminal

-a device capable of drawing lightning discharge in preference to vulnerable parts of the protected area.

Bonding

-a connection to accomplish electrical continuity.

PROTECTION AGAINST LIGHTNING

Conductors

- portion of the lightning system designed to carry lightning discharge.

Fastener

-an attachment to secure the conductor of the structure.

Flammable Vapors

- the vapors given from flammable liquid at or above its flashpoint.

PROTECTION AGAINST LIGHTNING

Ground Terminal

- portion of the system serving to bring the lightning protection system into electrical contact with the earth.

High-Rise Building

- building over 23 meter in height

Metal Body of Conductance

- metal objects at or above the eave or flat roof level that are subject to direct lightning stroke.

Metal Body Inductance

- metal objects located within 2000 mm of a conductor subject to build up of potential

PROTECTION AGAINST LIGHTNING

- Protection for Ordinary Buildings
- Protection for Miscellaneous Structures and Special Occupancies
- Protection for Heavy-Duty Stacks
- Protection for Structures Containing Flammable Liquids and Gases

Protection for Ordinary Buildings

- **MATERIALS**
  1. Copper
  2. Copper Alloys
  3. Aluminum
- **PREVENTION OF DETERIORATION**
  - protected by continuous hot dip of lead extending at least 6000 mm below the top of the chimney
- **AIR TERMINALS**
  - shall be provided for all parts of a structure that are likely to be damaged by lighting

Protection for Ordinary Buildings

- **AIR TERMINALS DESIGN AND SUPPORT**
  - ✓ Height:
    - ✓ tip not less than 254 mm above the object for 6000mm interval
    - ✓ tip not less than 600 mm above the object for 7600 mm interval
  - ✓ Supports
  - ✓ Ornaments
- **TERMINALS ON ROOFS**
  - ✓ Lower Roofs
  - ✓ Flat or gently sloping roofs

Protection for Ordinary Buildings

- **TERMINALS ON ROOFS**
  - ✓ Dormers
  - ✓ Roofs with intermediate ridges
  - ✓ Irregular roof lines
  - ✓ Open Areas in Flat Roofs
  - ✓ Domed or curved Structures
  - ✓ Chimneys

Protection for Ordinary Buildings

- **CONDUCTORS**

  -shall interconnect all air terminals and shall form a two-way path from each air terminal horizontally or downward

- **PREVENTING POCKETS**

  -conductors shall maintain a horizontal or downward course, free from "U" and "V" pockets

- **GRADUAL BENDS**

  -shall not form 90 degrees included angle or have radius of bend 203mm

Protection for Ordinary Buildings

- **DOWN CONDUCTORS**
  - ✓ Numbers of Down Conductors - average distance shall not exceed 30 m
  - ✓ Protecting Down Conductors - shall be protected for a minimum distance 1800 mm above grade
- **GROUNDING**
  - ✓ Ground terminals (rods) - not less than 12.7 mm diameter and 2400mm long. It is copper-clad steel, solid copper or stainless steel
  - ✓ Ground rod Clamps - shall make contact with the ground rod for a distance 38 mm

Protection for Miscellaneous Structures and Special Occupancies

- **MASS, SPIRES, FLAG POLES**
  - require 1 air terminal, down conductor and ground terminal
  - but for continuous metals, only ground terminal is required
- **TOWERS AND TANKS**
  - require bonding to ground terminals


THANK
YOU