

Welcome NC Electricians!

North Carolina Requirements

NC licenses [I, L, U, SP SFD]:

- 8 hours of continuing education every year
- Half of those hours from in-person or VILT classroom session(s)

NC licensees [SP-FA/LV, SP-EL, SP-PH, SP-WP, SP-ES, SP-SP]:

- 4 hours of continuing education every year
- Half of those hours from in-person or VILT classroom session(s)

Today’s class: 4 hours of classroom/VILT continuing education

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Installation Checklists

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7:45 AM – 8:10 AM Eastern	Registration / Check In / Intro
8:10 AM – 9:30 AM Eastern	Part I <i>with poll questions</i>
9:30 AM – 9:40 AM Eastern	Break
9:40 AM – 10:10 AM Eastern	Part II <i>with poll questions</i>
10:10 AM – 10:20 AM Eastern	Break
10:20 AM – 11:10 AM Eastern	Part III <i>with poll questions</i>
11:10 AM – 11:20 AM Eastern	Break
11:20 AM – 12:00 PM Eastern	Part IV <i>with poll questions</i>
12:00 PM Eastern	End of Class

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Underground - 300.5(F) Backfill.

Backfill cannot contain:

- large rocks
- paving materials
- cinders
- large/sharply angular substances
- corrosive material

These materials may:

- **damage** raceways, cables, conductors, or other substructures
- **prevent** adequate compaction of fill
- **contribute to corrosion** of raceways, cables, etc.



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300.5(F) Backfill.

To prevent damage to the raceway, cable, or conductor, protection shall be provided:

- granular or selected material
- suitable running boards
- suitable sleeves
- other approved means

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300.5(F) Backfill.

In rocky soil conditions, the inspection department often requires an additional shading inspection after a trench is approved to cover.

Bedding and shading the wiring method with **6 to 12 inches of sand** before refilling with poor quality backfill (initially removed from the trench) ensures protection of the wiring.

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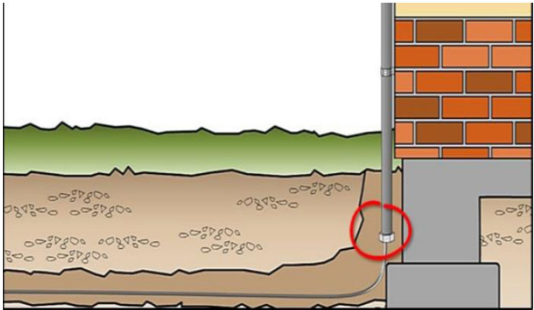
300.5(H) Bushings.

A bushing, or terminal fitting, with an integral bushed opening shall be used at the end of a conduit or other raceway that terminates underground where the conductors or cables emerge as a direct burial wiring method.

A seal incorporating the physical protection characteristics of a bushing shall be permitted to be used in lieu of a bushing.

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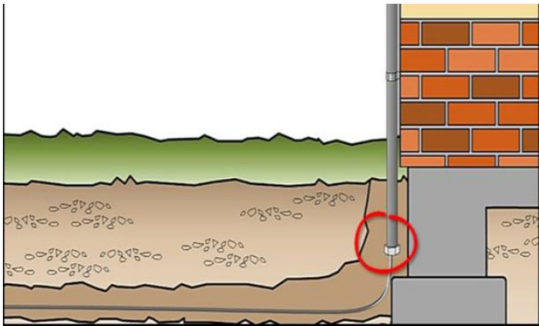
300.5(H) Bushings.

A raceway that terminates underground and emerges as a direct-burial cable requires a protective fitting to protect the cable from damage by the conduit.

Section 300.5(H) requires a bushing, connector, or terminal fitting with a bushed opening to serve this purpose.

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Underground Installations – Protection.

300.5(D)(1) requires protection for emerging cables from the minimum burial depth up to 8 feet above finished grade.

- Protection can be in the form of an enclosure or raceway.
- Damage can occur where the cable enters the raceway from the underground trench.

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from NEC Handbook

Type UF cable buried in compliance with Table 300.5

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300.5(J) Earth Movement.

Where direct-buried conductors, raceways, or cables are *subject to movement* by settlement or frost, direct-buried conductors, raceways, or cables shall be arranged to prevent damage to the enclosed conductors or to equipment connected to the raceways.

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300.5(J) Earth Movement.

Informational Note:

This section recognizes “S” loops in underground direct burial cables and conductors to raceway transitions, expansion fittings in raceway risers to fixed equipment, and the provision of flexible connections to equipment subject to settlement or frost heaves.

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Frost Heave, details

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300.5(J) Earth Movement.

Compensating for *expansion, contraction, earth settling, and frost heaves* ensures that wiring will not pull away from the terminals or pull equipment off the wall.

Where earth movement occurs due to frost or settlement, slack must be provided in cables and expansion joints used for raceways.

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Frost Heave, details

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Table 300.5 (A)

General Requirements for Wiring Methods and Materials of the NEC provides the minimum required cover distance over buried raceways, cables, and conductors.

Cover distance is the shortest distance measured between the top of the wiring method and finished grade.

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Table 300.5(A) Minimum Cover Requirements, 0 to 1000 Volts ac, 1500 Volts dc, Nominal, Burial in Millimeters (Inches)

Location of Wiring Method or Circuit	Type of Wiring Method or Circuit									
	Column 1 Direct Burial Cables or Conductors		Column 2 Rigid Metal Conduit or Intermediate Metal Conduit		Column 3 Electrical Metallic Tubing, Nonmetallic Raceways Listed for Direct Burial Without Concrete Encasement, or Other Approved Raceways		Column 4 Residential Branch Circuits Rated 120 Volts or Less with GFCI Protection and Maximum Overcurrent Protection of 20 Amperes		Column 5 Circuits for Control of Irrigation and Landscape Lighting Limited to Not More Than 30 Volts and Installed with Type UF or in Other Identified Cable or Raceway	
	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.

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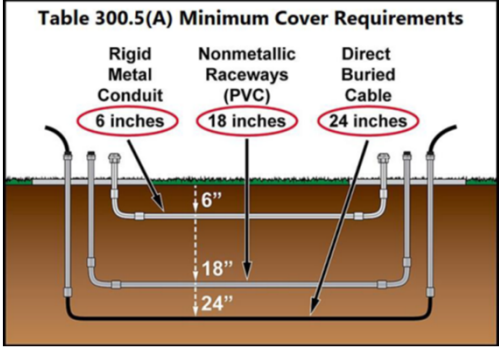
Table 300.5 (A).

- **Correct cover distance:**
trench depth greater than the minimum cover distance shown in the table
- Installations from 0 to 1000 volts ac and 0 to 1500 volts dc, covered by the table
- Empty spare raceways and low-voltage wiring methods included (unless specifically modified in NEC Chapters 7 and 8)

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Table 300.5(A) Minimum Cover Requirements



General Measurements for exterior wiring methods.

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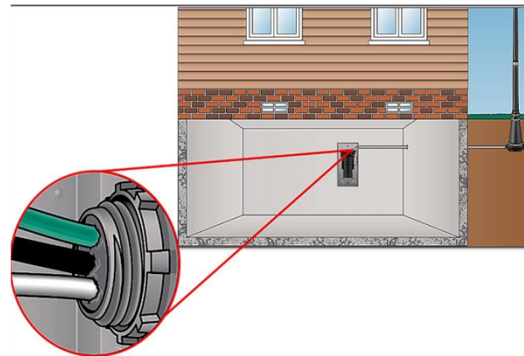
14

300.5(G) Raceway Seals.

- Conduits or raceways must be sealed or plugged at either or both ends
- Sealants must be for use with the cable insulation, conductor insulation, bare conductor, shield, etc.

Informational Note:

Presence of hazardous gases or vapors may also require sealing of underground conduits or raceways entering buildings.



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314.27(B) Floor Boxes.

Only boxes listed for floor installation are permitted for receptacles located in the floor.

Exception:

Where the AHJ judges them free from likely exposure to physical damage, boxes located in elevated floors of show windows and similar locations are permitted to be other than those listed for floor applications.



The NEC makes it clear that receptacles installed in the floor must be installed in boxes listed for the application.

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250.52(A)(3) Concrete-Encased Electrode.

Consists of at least 20 ft of either of the following:

(1) One or more bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than 1/2 in. in diameter, installed in one continuous 20 ft length, etc.

(2) Bare copper conductor not smaller than 4 AWG

4 AWG or larger bare copper conductor or steel reinforcing bar or rod not less than 1/2-in. diameter at least 20 ft long

Grounding electrode conductor

Nonmetallic protective sleeve

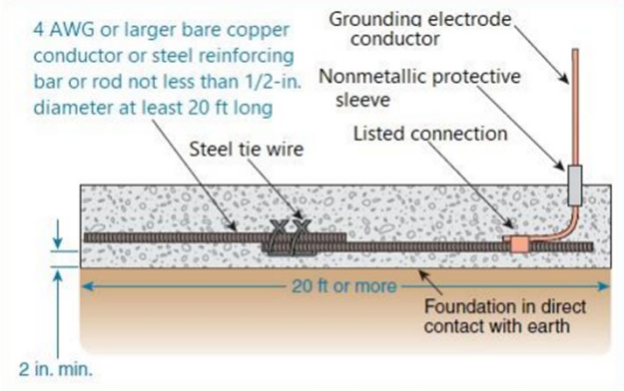
Listed connection

Steel tie wire

20 ft or more

Foundation in direct contact with earth

2 in. min.



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Rough Inspection



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250.52(A)(3) Concrete-Encased Electrode.

- 2 inches of concrete encasement
- Horizontal within concrete foundation or footing **in direct contact with the earth**
- Multiple concrete-encased electrodes--only one must be bonded to the grounding electrode system

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4 AWG or larger bare copper conductor or steel reinforcing bar or rod not less than 1/2-in. diameter at least 20 ft long

Grounding electrode conductor

Nonmetallic protective sleeve

Listed connection

Steel tie wire

2 in. min.

20 ft or more

Foundation in direct contact with earth

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250.52(A)(3) Concrete-Encased Electrode.

Informational Note:

Concrete installed with insulation, vapor barriers, films, or similar items separating the concrete from the earth is not considered to be in “direct contact” with the earth.

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At least 20 ft. of No. 4 AWG copper or 1/2" or larger rebar can be used as a concrete-encased electrode.

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A photograph showing a metal frame structure, possibly a door or partition, with a lock mechanism and a cable attached. The structure is made of silver-colored metal. A lock is visible on the left side, and a cable is connected to it. The background shows a workshop or factory setting with various equipment and materials.

The inspector will approve rough inspection in phases.

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517.13(A) Branch Circuits Serving Patient Care Areas.

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Branch-circuit wiring methods that comply:

- intermediate metal conduit
- rigid metal conduit
- electrical metallic tubing
- type AC cable
- listed healthcare-grade MC cables

Exception:

Luminaires more than 2.3 m (7-1/2 ft) above the floor and switches located outside of the patient care vicinity shall be permitted to be connected to an equipment grounding return path complying with the requirements of 517.13(A) or (B).

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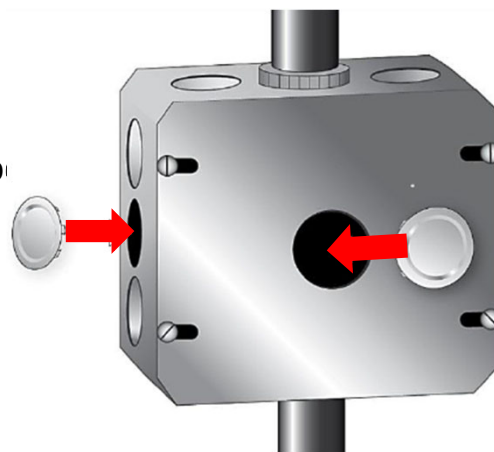
Rough Inspection - 110.12(A) Unused Openings.

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110.12 Mechanical Execution of Work.

(A) Unused Openings.

Where metallic plugs or plates are used with nonmetallic enclosures, they shall be recessed at least 1/4 in. from the outer surface of the enclosure.



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****Please review this Code section in your NEC manual and in the course handout.***

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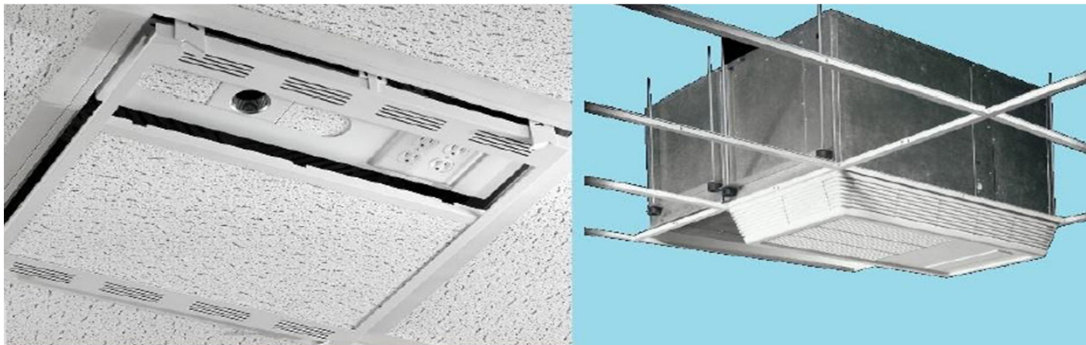
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Article 100 Definitions: Accessible.



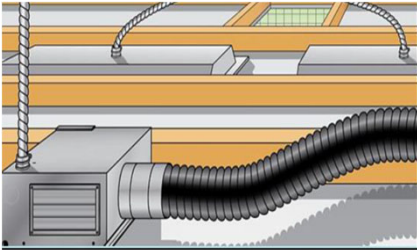
Examples of equipment that would not have met the definition of accessible in NEC-2017 and now meet that definition

Examples of equipment that would not have met the definition of accessible in NEC-2017 and now meet that definition

Article 100 Definitions: Accessible.

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The illustration shows a cross-section of a building's ceiling and floor. A metal junction box is mounted on the ceiling, with a flexible conduit leading down to a floor-mounted electrical panel. The conduit is shown in a way that demonstrates its accessibility for removal or exposure without damaging the building structure.



2023 National Electrical Code®

Accessible (as applied to equipment). Capable of being reached for operation, renewal, and inspection. (CMP-1)

Accessible (as applied to wiring methods). Capable of being removed or exposed without damaging the building structure or finish or not permanently closed in or blocked by the structure, other electrical equipment, other building systems, or finish of the building. (CMP-1)

Junction boxes above a hard lid ceiling, bonding connections to exposed structural steel, water, and gas pipe must be accessible. Often a permanent access hole will be required.

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Article 100 Definitions: Accessible.

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Examples of items required to be accessible in the NEC:

- Wiring Methods with Interior Access, 300.15(A)
- Boxes, Conduit Bodies, and Handhole Enclosures to Be Accessible, 314.29
- Grounding Electrode Conductor, Multiple Separately Derived Systems, 250.30(A)(6)
- Bonding of Piping Systems and Exposed Structural Metal, 250.104
- Cable Trays; Exposed and Accessible, 392.18(E).

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300.4(A)(1) Cables and Raceways Through Wood Members; Bored Holes.

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Where cables or raceways (other than RMC, IMC, RNC and EMT) are installed through bored holes, the hole must be drilled with the closest edge at least 1-1/4 inches from the nearest edge of the stud, joist, or rafter.

Exception No. 1: Steel plates shall not be required to protect rigid metal conduit, intermediate metal conduit, rigid PVC conduit, RTRC, or electrical metallic tubing.

Exception No. 2: A listed and marked steel plate less than 1.6 mm (1/16 in.) thick that provides equal or better protection against nail or screw penetration shall be permitted.

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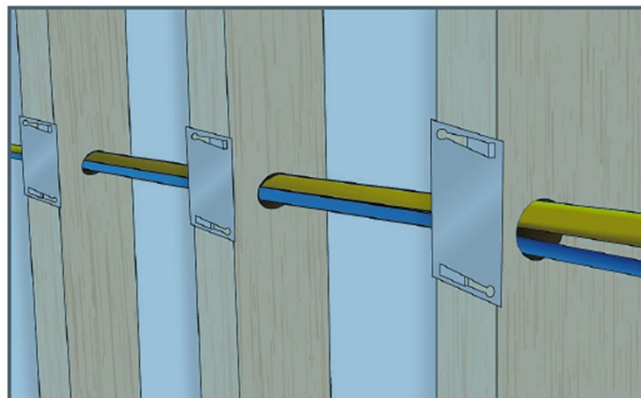
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300.4(A)(1) Cables and Raceways Through Wood Members; Bored Holes.

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Cables installed through bored holes less than 1-1/4 inches from nearest edge of the stud must have nail protection.

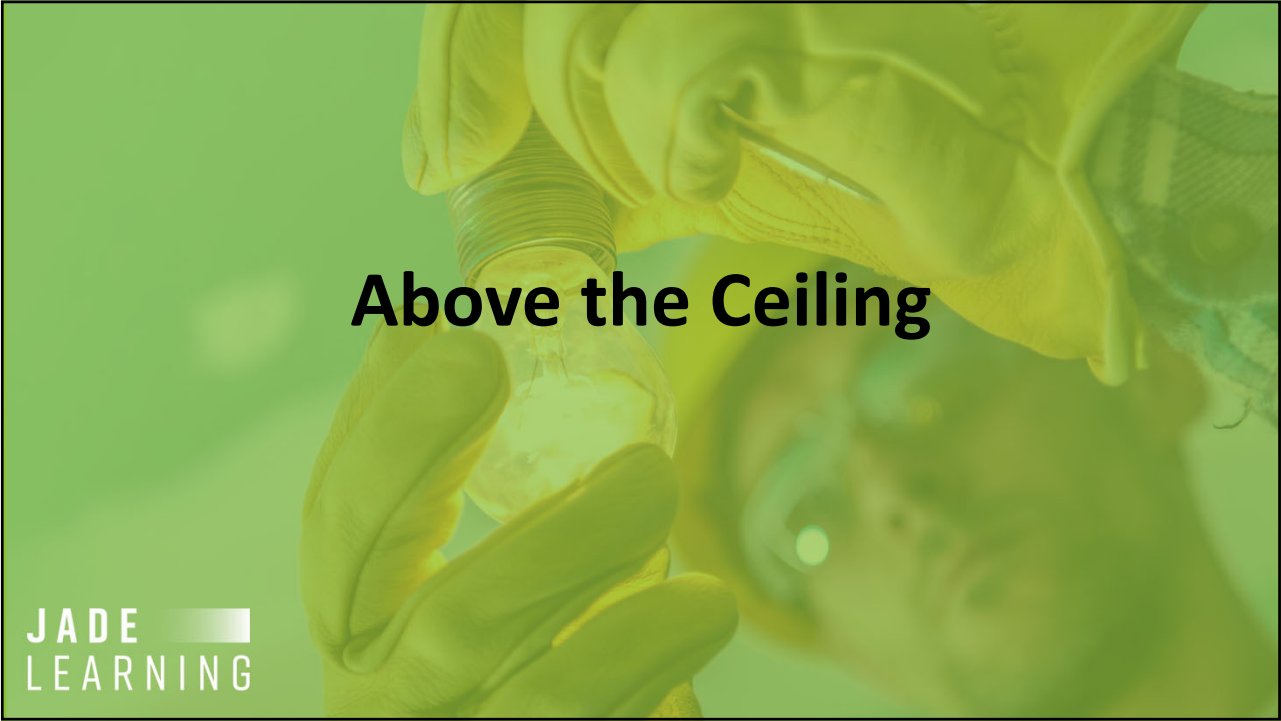
- Prevents nails and screws from being driven into conductors, cables, and raceways



****Please review this Code section in your NEC manual and in the course handout.***

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300.11(A)&(B) Secured In Place.

Raceways, cable assemblies, boxes, cabinets, and fittings shall be securely fastened in place.

Wiring methods used above suspended ceilings have specific requirements for rated vs. non-rated assemblies.

Ceiling grid systems: support wire on the main T-bar runner within 8 inches of the wall and every 4 feet thereafter for 12-gauge support wires and every 5 feet for 10-gauge support wires.

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200.4(B) Multiple Circuits.

2023 National Electrical Code (NEC)[®]

Article 200 Use and Identification of Grounded Conductors

200.4 Neutral Conductors. Neutral conductors shall be installed in accordance with 200.4(A) and (B).

(A) Installation. Neutral conductors shall not be used for more than one branch circuit, for more than one multiwire branch circuit, or for more than one set of ungrounded feeder conductors unless specifically permitted elsewhere in this Code.

Informational Note: See 215.4 for information on common neutrals.

Neutral conductors must be grouped with their associated ungrounded conductors in the enclosure.

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200.4(B) Multiple Circuits.

Neutral conductors are not generally allowed to be switched like ungrounded conductors through overcurrent devices or other switches.

Exceptions:

- Neutrals in cables or other raceways that are unique to the circuit so that grouping is obvious
- Pass-through conductors without a loop that are not spliced or terminated in the box



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424.66/110.26(A)(4) Duct Heaters with Limited Access Above Ceiling/Working Space; Limited Access.

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Working space for duct heaters with limited access above ceiling

- Replacement of controls and heating elements
- Adjusting and cleaning controls and other parts



Working space is required above the ceiling at duct heaters.

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Sections 424.66/110.26(A)(4).

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(1) Accessible through access panel, 22 inches square for a lay-in type ceiling or 22 x 30 inches for crawl space

(2) *Working space*--width of the enclosure or minimum of 30 inches, whichever is greater

(3) Doors, hinged panels must open to 90 degrees.

(4) The space in front of the enclosure shall comply with the depth requirements of Table 110.26(A)(1) and shall be unobstructed to the floor by fixed cabinets, walls, or partitions. Space reductions in accordance with 110.26(A)(1)(b) shall be permitted. The maximum height of the working space shall be the height necessary to install the equipment in the limited space. A horizontal ceiling structural member or access panel shall be permitted in this space, provided the location of weight-bearing structural members does not result in a side reach of more than 150 mm (6 in.) to work within the enclosure.

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Type IC Luminaire (LED)

This diagram shows a cross-section of a ceiling assembly. A silver, cylindrical LED luminaire is mounted on a metal track. The luminaire is positioned within a recessed area of the ceiling, which is filled with red insulation. The ceiling structure is composed of yellow panels and a grey layer. The luminaire is shown without any external wiring or conduit.

Non-Type IC Luminaire (LED)

This diagram shows a cross-section of a ceiling assembly. A silver, cylindrical LED luminaire is mounted on a metal track. The luminaire is positioned within a recessed area of the ceiling, which is filled with red insulation. The ceiling structure is composed of yellow panels and a grey layer. The luminaire is shown with a black cable connected to its base, indicating it is not a Type IC luminaire.

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Type IC Luminaire (LED)

This diagram shows a cross-section of a wall and ceiling assembly. The wall consists of a red insulation layer, a tan vertical stud, and a grey exterior finish. The ceiling consists of a red insulation layer, a tan horizontal joist, and a grey interior finish. A silver, cylindrical luminaire is mounted on a track that is attached to the ceiling joist. The luminaire is positioned such that its heat is directed into the ceiling cavity, which is filled with red insulation.

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590.3(D) Removal of Temporary Wiring.

2023 National Electrical Code (NEC)[®]

Article 590 Temporary Installations

590.3 Time Constraints.

(A) During the Period of Construction. Temporary electric power and lighting installations shall be permitted during the period of construction, remodeling, maintenance, repair, or demolition of buildings, structures, equipment, or similar activities.

(B) 90 Days. Temporary electric power and lighting installations shall be permitted for a period not to exceed 90 days for holiday decorative lighting and similar purposes. The 90-day time limit applies only to temporary electrical installations associated with holiday displays. Other installations are not bound by this time limit.

(C) Emergencies and Tests. Temporary electric power and lighting installations shall be permitted during emergencies and for tests, experiments, and developmental work.

(D) Removal. Temporary wiring shall be removed immediately upon completion of construction or purpose for which the wiring was installed.

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590.3(D) Removal of Temporary Wiring.

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- Temporary wiring installed during construction phase must be removed before final inspection.
- Temporary wiring installations may be modified so they do not meet all the requirements for a permanent installation—

all temporary wiring must not only be disconnected but also removed from the building, structure, or other location of installation.



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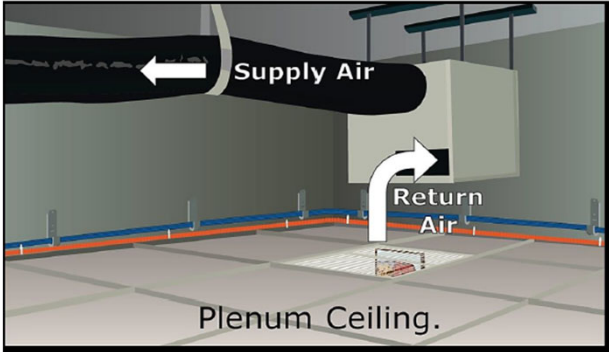
300.22(C) Other Spaces Used for Environmental Air.

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A *plenum* exists when return air is pulled through the above-ceiling space—before entering the HVAC unit installed above the ceiling grid—where it is conditioned and supplied back through the building.

Space above a suspended ceiling may function as a plenum.



Supply Air

Return Air

Plenum Ceiling.

****Please review this Code section in your NEC manual and in the course handout.***

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300.22(C) Other Spaces Used for Environmental Air.

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Wiring methods in a plenum-type ceiling:

- Totally enclosed, nonventilated, insulated busway having no provisions for plug-in connections
- Type MI cable without an overall nonmetallic covering
- Type MC cable without an overall nonmetallic covering
- Type AC cable

***(1) Wiring Methods.** The wiring methods for such other space shall be limited to totally enclosed, nonventilated, insulated busway having no provisions for plug-in connections, Type MI cable without an overall nonmetallic covering, Type MC cable without an overall nonmetallic covering, Type AC cable, or other factory-assembled multiconductor control or power cable that is specifically listed for use within an air-handling space, or listed prefabricated cable assemblies of metallic manufactured wiring systems without nonmetallic sheath. Other types of cables, conductors, and raceways shall be permitted to be installed in electrical metallic tubing, flexible metallic tubing, intermediate metal conduit, rigid metal conduit without an overall nonmetallic covering, flexible metal conduit, or, where accessible, surface metal raceway or metal wireway with metal covers.*

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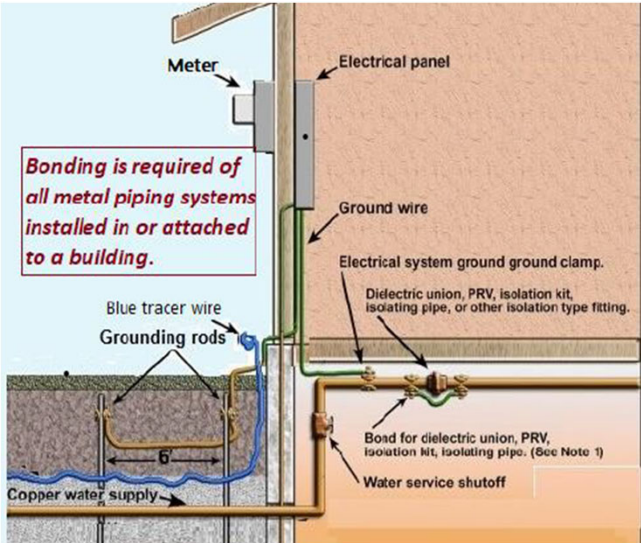
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250.104(A)(B)(C) Bonding of Piping and Exposed Structural Steel.

Must be bonded:

- A. Metal water piping—
points of attachment of the bonding jumper must be accessible
- B. Other metal piping—
required if the piping system is *likely to become energized*
- C. Structural metal—
exposed structural metal
- D. Separately derived systems



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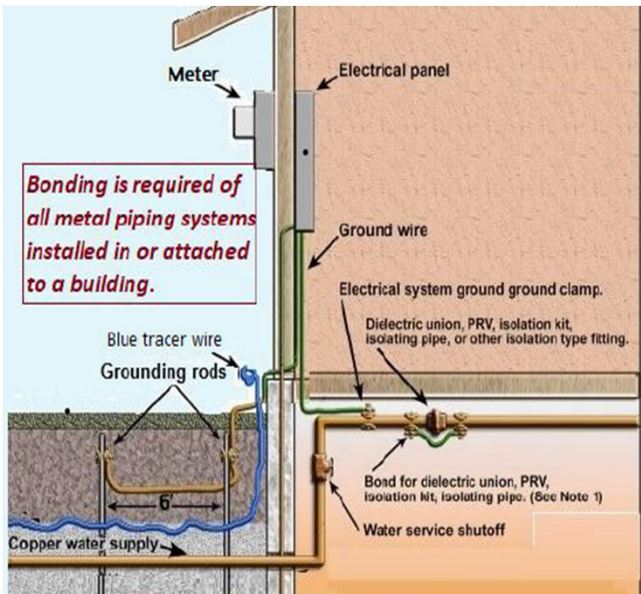
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250.104(A)(B)(C) Bonding of Piping and Exposed Structural Steel.

Metal piping systems can be bonded to:

- equipment grounding conductor for the circuit that is likely to energize the piping system
- service equipment enclosure
- grounded conductor at the service
- grounding electrode conductor, if of sufficient size
- one or more grounding electrodes used.



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250.104 (C) Bonding of Piping and Exposed Structural Steel.

Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounded Conductor or Bonding Jumper* (AWG/kcmil)	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	See Notes 1 and 2.	

4. Grounding electrode conductor, if not smaller than a conductor sized in accordance with Table 250.102(C)(1)

5. One or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is not smaller than a conductor sized in accordance with Table 250.102(C)(1)

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410.117(C) Luminaires; Tap Conductors.

2023 National Electrical Code (NEC)®
Article 410 Luminaires, Lampholders, and Lamps
410.117 Wiring.
(C) Tap Conductors. Tap conductors of a type suitable for the temperature encountered shall be permitted to run from the luminaire terminal connection to an outlet box placed at least 300 mm (1 ft) from the luminaire. Such tap conductors shall be in suitable raceway or Type AC or MC cable of at least 450 mm (18 in.) but not more than 1.8 m (6 ft) in length.

No. 12 AWG copper MC cable used between fixtures and to the final junction box instead of the factory-made No. 18 AWG fixture whips.

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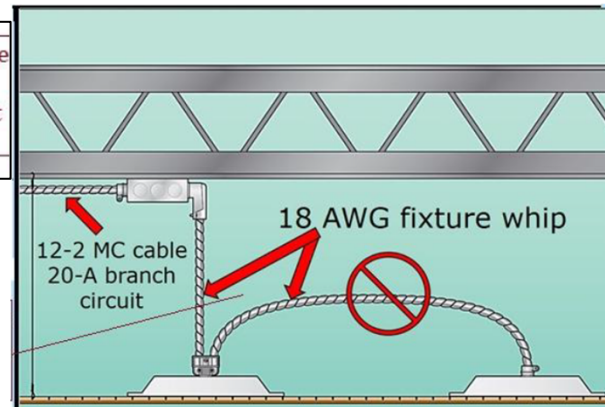
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410.117(C) Luminaires; Tap Conductors.

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No. 18 AWG fixture whips can connect one luminaire to the junction box where the 20 amp circuit is present, but they cannot be used to daisy chain from light to light.

**No. 12 AWG copper MC cable is used between fixtures and to the final junction box instead of the factory-made No. 18 AWG fixture whips.*



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300.21 Spread of Fire or Products of Combustion.

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Openings around electrical penetrations into/through fire-resistant rated walls, partitions, floors, or ceilings must be fire-stopped.

Penetrations through rated walls, ceilings, floor/ceiling assemblies, etc. are covered by the NEC to ensure that the spread of fire or products of combustion are not substantially increased by any wiring methods the electrician may install on a project.



Not all fire-rated walls will be identifiable as being rated. Check plans for locations of any rated walls that might be present before penetrating them.

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Rooftop

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Rooftop - 250.12 Clean Surfaces.



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250.12 Clean Surfaces. Nonconductive coatings (such as paint, lacquer, and enamel) on equipment to be grounded or bonded shall be removed from threads and other contact surfaces to ensure good electrical continuity or shall be connected by means of fittings designed to make such removal unnecessary.

Locknut designed to cut through painted surfaces when tightened



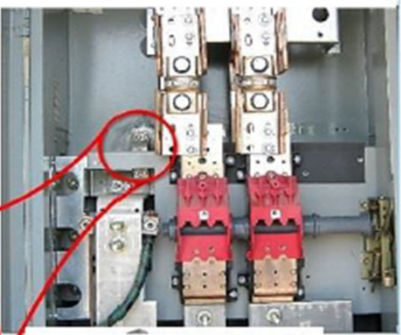
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Rooftop - 250.12 Clean Surfaces.

- Certain fittings can be designed for good electrical continuity to the contact surface through nonconductive coatings.
- Field drilled holes in metal enclosures require paint removal before the grounding terminal is attached.



Scraping paint for a good metal-to-metal connection ensures an effective ground-fault current path

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250.97 Bonding for Over 250 Volts.

Exception: If oversized, concentric, or eccentric knockouts are not encountered the following methods are permitted:

(1) Threadless couplings and connectors for cables with metal sheaths

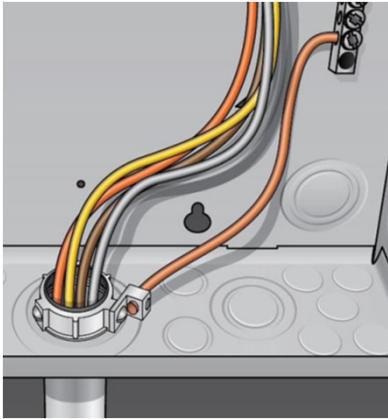
(2) 2 locknuts, on rigid metal conduit or intermediate metal conduit

(3) Fittings with shoulders that seat tightly against the box or cabinet with one locknut on the inside of boxes and cabinets

(4) Listed fittings

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440.4(B) Marking on HVAC Equipment.

Multimotor and combination-load:

• visible nameplate with maker’s name, rating in volts, frequency, number of phases

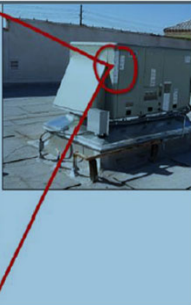
• min. supply circuit conductor ampacity

• max. rating of branch-circuit short-circuit and ground-fault protective device

• short-circuit current rating of motor controllers or industrial control panel

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MODEL NO. /	13AJN60A01	MFD./FAB	05/2013
SERIAL NO. /	8395W221316080	OUTDOOR USE /	USAGE EXTÉRIEUR
VOLTS	208/230	PHASE	1 HERTZ 60
COMPRESSOR /			
COMPRESSEUR	R.L.A. 26.4/26.4	L.R.A.	134.0
OUTDOOR FAN MOTOR /			
MOTEUR VENTIL. EXT.	F.L.A. 1.20	HP.	1/5
MIN. SUPPLY CIRCUIT AMPACITY /			
COURANT ADMISSIBLE D'ALIM. MIN.		35/35	AMP
MAX. FUSE OR CKT. BRK. SIZE* /			
CAL. MAX. DE FUSIBLE/DISJ*		60/60	AMP
MIN. FUSE OR CKT. BRK. SIZE* /			
CAL. MIN. DE FUSIBLE/DISJ*		45/45	AMP

When the minimum circuit ampacity and maximum size OCPD are marked on the nameplate, no additional math or calculation is required.

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314.23(E)&(F) Raceway Supported Enclosures.

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2023 National Electrical Code (NEC)[®]

Article 314 Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; Fittings; and Handhole Enclosures

314.23 Supports.

(F) Raceway-Supported Enclosures, with Devices, Luminaires, or Lampholders. An enclosure that contains a device(s), other than splicing devices, or supports a luminaire(s), a lampholder, or other equipment and is supported by entering raceways shall not exceed 1650 cm³ (100 in.³) in size. It shall have threaded entries or identified hubs. It shall be supported by two or more conduits threaded wrenchtight into the enclosure or hubs. Each conduit shall be secured within 450 mm (18 in.) of the enclosure.

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314.23(E)&(F) Raceway Supported Enclosures.

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An enclosure can be supported by raceways if:

- the enclosure is supported by 2 or more conduits threaded wrench-tight into the enclosure or hubs that are part of the enclosure.
- the enclosure is not greater than 100 cubic inches.
- the enclosure contains only splices--each conduit must be secured within 3 feet of the enclosure or within 18 inches of the enclosure if all conduit entries are on the same side.



Box (not a conduit body)

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314.23(E)&(F) Raceway Supported Enclosures.

Exception—
applies to conduit bodies, not boxes.

(1) Intermediate metal conduit, Type IMC

(2) Rigid metal conduit, Type RMC

(3) Rigid polyvinyl chloride conduit, Type PVC

(4) Reinforced thermosetting resin conduit, Type RTRC

(5) Electrical metallic tubing, Type EMT



Box (not a conduit body)

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314.23(E)&(F) Raceway Supported Enclosures.

Another exception permits an unbroken length of RMC or IMC to support a box used for luminaire or lampholder support.

- A box is not permitted to be supported by a single raceway.
- Boxes are also not permitted to be supported by rigid raceways using locknuts and bushings.

Only rigid metal conduit (RMC) and intermediate metal conduit (IMC) have threads.



Conduit body

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A diagram of a rooftop HVAC unit. A circular inset shows a close-up of a disconnect switch mounted on the side of the unit, which is plugged into a standard wall outlet. Another circular inset shows a close-up of the disconnect switch's internal components, including a red emergency stop button and a white reset button.

It cannot be connected to the load side of the equipment disconnecting means.

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210.63(A) Heating, Air-Conditioning, and Refrigeration Equipment Outlet.

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The diagram illustrates the connection of a portable generator to a building's electrical system. A generator is shown on the ground, connected via a cable to a transfer switch located inside the building. An inset shows the transfer switch being moved to the 'Generator' position, indicating the correct setup for using the generator as a power source.

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110.24 Available Fault Current.

- Overcurrent devices are marked with their designated trip setting as well as an ampere interrupting capacity (AIC).
- The AIC rating is the maximum amount of current the device can interrupt without blowing up. A 20-amp circuit breaker for example, may also be marked 10,000 AIC.

Exception: The field marking requirements in 110.24(A) and 110.24(B) are not required in industrial installations.

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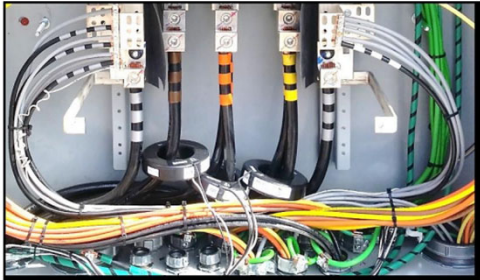
200.6 Identification of Grounded Conductors.

Provides rules on identifying grounded neutral conductors.

Sizes No. 6 AWG or smaller—

- continuous white outer finish
- continuous gray outer finish
- three continuous white or gray stripes along the conductor’s entire length on other-than-green insulation

Sizes No. 4 AWG or larger—
same as above or by a white or gray marking at its terminations that encircles the conductor insulation



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Properly Identified Wire-Type Equipment Grounding Conductor

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Properly Identified Wire-Type Equipment Grounding Conductor

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250.119 Identification of Equipment Grounding Conductors.

(C) One or more insulated conductors in a multiconductor cable are permitted to be permanently identified as equipment grounding conductors at each end/at every point where the conductors are accessible by one of the following:

- (1) Stripping the insulation from the entire exposed length.
- (2) Coloring the exposed insulation green.
- (3) Marking the exposed insulation with green tape or green adhesive labels. Identification shall encircle the conductor.



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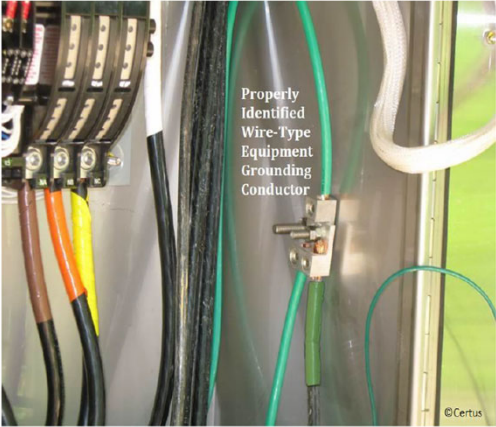
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250.119 Identification of Equipment Grounding Conductors.

(D) Flexible Cord.

Equipment grounding conductors in flexible cords shall be insulated and shall have a continuous outer finish that is either green or green with one or more yellow stripes.



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Bare, green, or green with one or more yellow stripes are proper identification methods for equipment grounding conductors.

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210.5(C)(1) & 235.5(C)(1) Identification of Ungrounded Conductors.

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REC. 7E50 NURSE STATION

36

SPARE

37

SPARE

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SPARE

39

SPARE

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SPARE

41

SPARE

42

SPARE

7A-2D 7E50ER 120/208V

PHASE A - BLACK

PHASE B - RED

PHASE C - BLUE

EC4-1DXB
480/277V

PHASE A - BROWN

PHASE B - ORANGE

PHASE C - YELLOW

MET

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235.5(C)(1) Identification of Ungrounded Conductors.

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REC. 7E50 NURSE STATION

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SPARE

37

SPARE

38

SPARE

39

SPARE

40

SPARE

41

SPARE

42

SPARE

7A-2D 7E50ER 120/208V

PHASE A - BLACK

PHASE B - RED

PHASE C - BLUE

EC4-1DXB
480/277V

PHASE A - BROWN

PHASE B - ORANGE

PHASE C - YELLOW

MET

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110.26(A)(1) Working Space.

Section addresses equipment rated 600 volts or less to ground that is likely to be examined, adjusted, serviced, or maintained while energized.

Open equipment doors shall not impede access to and egress from the working space.

Access or egress is *impeded* if one or more simultaneously opened equipment doors restrict working space access to be less than 24 inches wide and 6-1/2 feet high.



Section 110,26 is updated for the 2023 edition to clarify access and egress requirements, taking into account the space needed to open equipment doors

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110.26(A)(1) Working Space.

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2023 National Electrical Code (NEC) [®]			
Table 110.26(A)(1) Working Spaces			
Nominal Voltage to Ground	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
0–150	900 mm (3 ft)	900 mm (3 ft)	900 mm (3 ft)
151–600	900 mm (3 ft)	1.0 m (3 ft 6 in.)	1.2 m (4 ft)
601–1000	900 mm (3 ft)	1.2 m (4 ft)	1.5 m (5 ft)

Note: Where the conditions are as follows:

Condition 1 — Exposed live parts on one side of the working space and no live or grounded parts on the other side of the working space, or exposed live parts on both sides of the working space that are effectively guarded by insulating materials.

Condition 2 — Exposed live parts on one side of the working space and grounded parts on the other side of the working space. Concrete, brick, or tile walls shall be considered as grounded.

Condition 3 — Exposed live parts on both sides of the working space.

Working space must comply with the dimensions shown in Table 110.26(A)(1).

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250.30(A)(1) System Bonding Jumpers.

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(1) System Bonding Jumper

An unspliced system bonding jumper shall comply with 250.28(A) through (D). This connection shall be made at any single point on the separately derived system from the source to the first system disconnecting means or overcurrent device, or it shall be made at the source of a separately derived system that has no disconnecting means or overcurrent devices, in accordance with 250.30(A)(1)(a) or (A)(1)(b). The system bonding jumper shall remain within the enclosure where it originates. If the source is located outside the building or structure supplied, a system bonding jumper shall be installed at the grounding electrode connection in compliance with 250.30(C).

Article 100 defines a separately derived system as an electrical source, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections.

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250.30(A)(1) System Bonding Jumpers.

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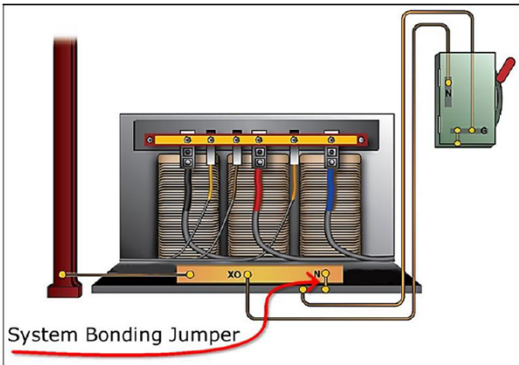
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Exception No. 1:

For systems installed in accordance with 450.6, a single system bonding jumper connection to the tie point of the grounded circuit conductors from each power source shall be permitted.

Exception No. 2:

If a building or structure is supplied by a feeder from an outdoor separately derived system, a system bonding jumper at both the source and the first disconnecting means shall be permitted if doing so does not establish a parallel path for the grounded conductor.



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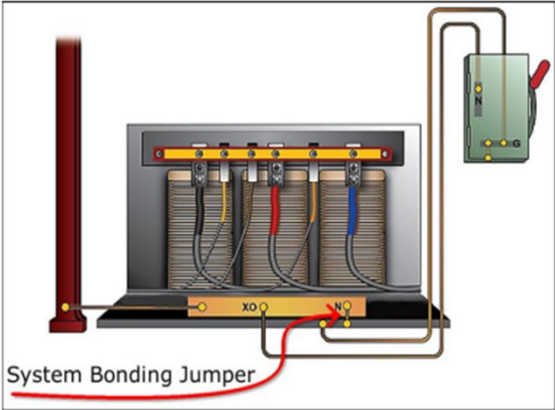
250.30(A)(1) System Bonding Jumpers.

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Exception No. 3:

The size of the system bonding jumper for a system that supplies a Class 1, Class 2, or Class 3 circuit, and is derived from a transformer rated not more than 1000 volt-amperes, shall not be smaller than the derived ungrounded conductors and shall not be smaller than 14 AWG copper or 12 AWG aluminum.



The diagram shows a transformer with multiple secondary windings. A red wire, labeled 'System Bonding Jumper', connects the grounded neutral point (marked 'N') to the metal frame of the transformer. Other wires (yellow, red, blue) are connected to the secondary terminals. A green control box is connected to the primary side of the transformer.

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Section 250.30(A)(4)&(5)

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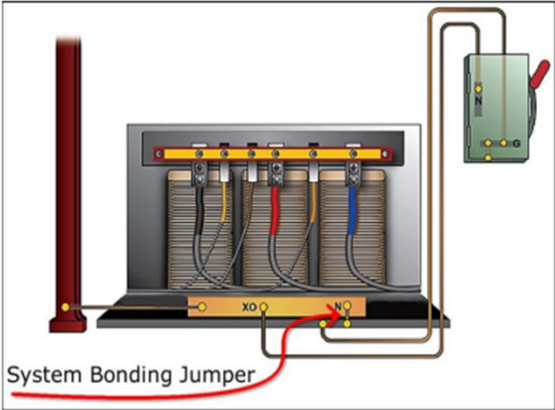
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(4) Grounding Electrode

The building or structure grounding electrode system shall be used as the grounding electrode for the separately derived system. If located outdoors, the grounding electrode shall be in accordance with 250.30(C).

Exception:

If a separately derived system originates in equipment that is listed and identified as suitable for use as service equipment, the grounding electrode used for the service or feeder equipment shall be permitted to be used as the grounding electrode for the separately derived system.



The diagram shows a transformer with multiple secondary windings. A red wire, labeled 'System Bonding Jumper', connects the grounded neutral point (marked 'N') to the metal frame of the transformer. Other wires (yellow, red, blue) are connected to the secondary terminals. A green control box is connected to the primary side of the transformer.

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Section 250.30(A)(4)&(5)

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(5) Grounding Electrode Conductor, Single Separately Derived System

A grounding electrode conductor for a single separately derived system is sized in accordance with 250.66 for the derived ungrounded conductors.

It is used to connect the grounded conductor of the derived system to the grounding electrode in accordance with 250.30(A)(4), or as permitted in 250.68(C)(1) and (C)(2).

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Section 250.30(A)(4)&(5)

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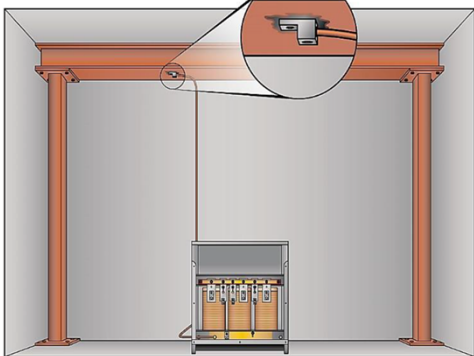
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This Section provides the rules on how to ground a separately derived system (SDS) to earth.

The grounding electrode conductor must connect to the grounded conductor of the separately derived system at the same location as the SBJ.

If the SBJ is located in the transformer, the grounding electrode conductor coming from the grounding electrode must terminate there.

If the SBJ is located in the first disconnecting means downstream of the transformer, the GEC must terminate there.



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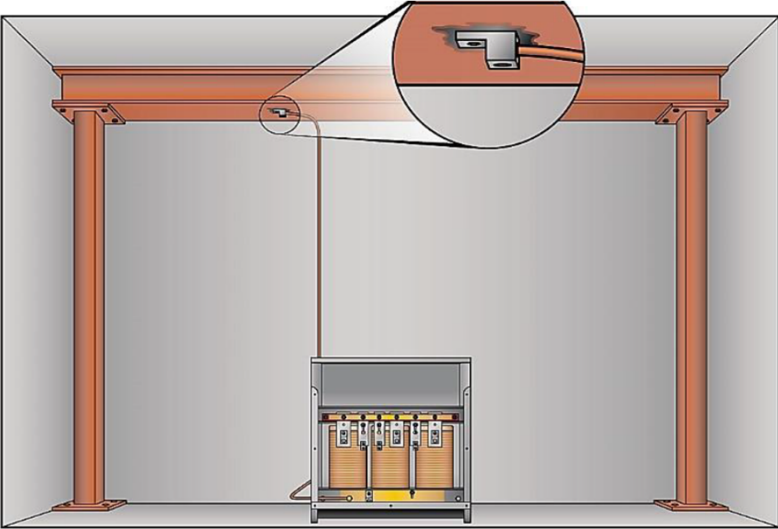
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Section 250.30(A)(4)&(5)

Grounding electrode conductors are sized from NEC **Table 250.66**, based on the size of the transformer’s ungrounded secondary conductors.

They are never required to be larger than 3/0 AWG copper or 250 kcmil aluminum.



The grounding electrode conductor is connecting the nearby structural steel grounding electrode to the system bonding jumper.

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Final Inspection

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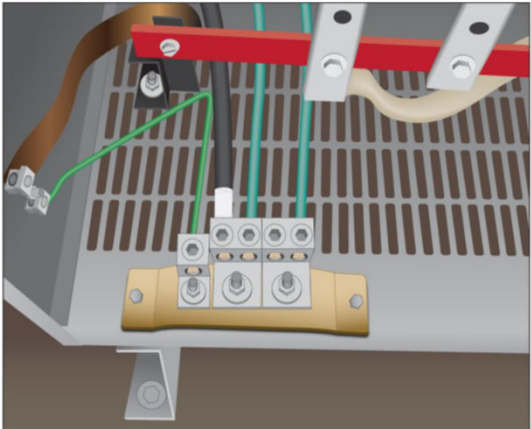
450.10(A) Grounding of Dry-Type Transformer Enclosures.

A terminal bar for all grounding and bonding conductor connections must be secured inside the transformer enclosure where separate equipment grounding conductors and supply-side bonding jumpers are installed.

- Terminal bar must be bonded to the enclosure [in accordance with 250.12].
- It cannot be installed on or over any vented portion of the enclosure.

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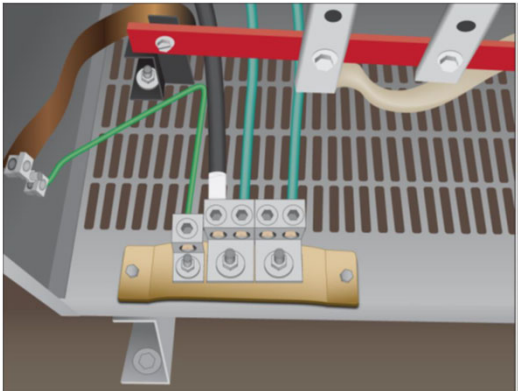
95

450.10(A) Grounding of Dry-Type Transformer Enclosures.

- Bonding terminals installed over perforated metal creates an impaired metal-to-metal connection that can interfere with the ventilation of the transformer coils.
- Proper grounding and bonding of a transformer ensures an effective ground-fault current path in the event of a fault condition.

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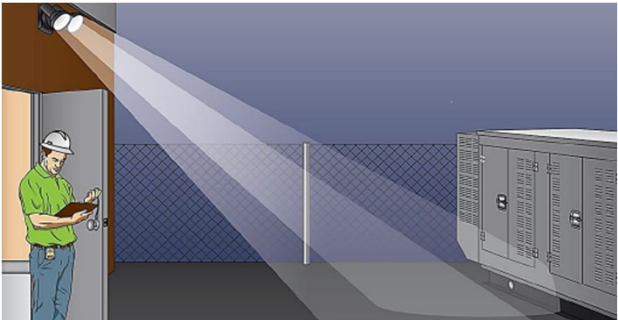
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700.12 General Requirements.

Current supply must be such that—in the event of failure of the normal supply to a building—emergency power must be available within the time required (not to exceed 10 seconds).

(A) Power Source Considerations

(B) Equipment Design and Location



COURSE TITLE

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700.12 General Requirements.

For emergency lighting, at least two sources of power must be provided:

1. Normal source of supply (usually the utility)
2. One or more of the emergency systems described in 700.12, which can be:
 - a. sourced from a separate utility.
 - b. storage battery or unit equipment system.
 - c. a generator set

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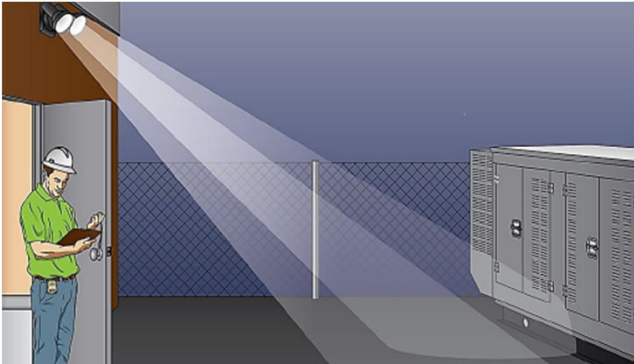
700.12 General Requirements.

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The electrical inspector, building inspector, or the fire marshal may be responsible for final testing and acceptance of the emergency system in a building.

The most common way to test a generator for backup power for emergency lighting and power systems is for the inspector to stand at an exit with the door open, at a place in the building closest to the outdoor generator.



An illustration showing an electrical inspector in a green shirt and blue pants, wearing a hard hat, standing in a doorway. He is holding a clipboard and looking at a light fixture mounted on the wall. A beam of light from the fixture is shown illuminating the area outside the door. Outside the door, there is a chain-link fence and a large outdoor generator unit.

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700.16 Emergency Illumination, Part 1.

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One of the most common correction concerns at a final inspection: emergency lighting and exit signs (unit equipment) not functioning as intended.

The electrician must remember to connect all battery leads in the emergency fixtures so they can charge for the final inspection.

Emergency lighting installed to back up high-intensity discharge (HID) lighting that provides normal area illumination.

NOTES BY SYMBOL "⬡"

1. REFER TO DETAIL 2, SHEET E1.1 FOR MORE INFORMATION.

2. INSTALL EMERGENCY LIGHT FIXTURE WITH THREE INTERNAL LAMPS AT 8'-0" ABOVE FINISHED FLOOR TO CENTER OF FIXTURE. UPON LOSS OF POWER, FIXTURE SHALL PROVIDE EMERGENCY EGRESS LIGHTING VIA INTEGRAL BATTERY PACK. FIXTURE SHALL ALSO CONTAIN A TIME DELAY MONITOR. UPON RETURN OF NORMAL POWER TO THE BUILDING THE TIME DELAY MONITOR SHALL KEEP THE FIXTURE ENERGIZED FOR A MINIMUM OF FIFTEEN MINUTES TO ALLOW NORMAL POWER LIGHT FIXTURES TO RETURN TO FULL BRIGHTNESS.

LIGHTING FIXTURE SCHEDULE

TYPE	DESCRIPTION	LAMPS	BALLAST	WATTS
A	2' X 4' LAY-IN FLUORESCENT EQUIPPED WITH PRISMATIC LENS, 120 VOLT; METALUX # 2GR8-232A125-120-EB81	TWO F032T8 3500K	ELECTRONIC	59
A1	2' X 4' LAY-IN FLUORESCENT EQUIPPED WITH PRISMATIC LENS, 120 VOLT;	TWO F032T8	ELECTRONIC	59

If the HID luminaire providing normal area illumination does not have an instant quartz restrike lamp, an emergency light with a time delay feature should be selected.

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700.16 Emergency Illumination, Part 1.

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(A) General. Emergency lighting systems shall be designed and installed so that the failure of any individual lighting element, such as the burning out of a lamp, cannot leave in total darkness any space that requires emergency illumination.

(C) Discharge Lighting. Where high-intensity discharge lighting such as high- and low-pressure sodium, mercury vapor, and metal halide is used as the sole source of normal illumination, the emergency lighting system shall be required to operate until normal illumination has been restored.

If HID luminaires are the sole source of normal illumination in an area, emergency lighting systems are not only required to operate until the normal system returns to service but also until the HID luminaires become fully operational.

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700.16 Emergency Illumination, Part 2.

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(B) System Reliability. Emergency lighting systems shall be designed and installed so that the failure of any illumination source cannot leave in total darkness any space that requires emergency illumination. Emergency lighting control devices in the emergency lighting system shall be listed for use in emergency systems. Listed unit equipment in accordance with 700.12(H) shall be considered as meeting the provisions of this section.

Informational Note: See 700.23 through 700.26 for applications of emergency system control devices.

(D) Disconnecting Means. Where an emergency system is installed, emergency illumination shall be provided in the area of the disconnecting means required by 225.31 and 230.70, as applicable, where the disconnecting means are installed indoors.

Exception: Alternative means that ensure that the emergency lighting illumination level is maintained shall be permitted.

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700.16 Emergency Illumination, Part 2.

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• Emergency lighting must be arranged so that failure of any individual lighting element does not leave any space that requires emergency illumination in total darkness.

• Many luminaires function to provide normal area lighting and have a battery backup so they can double as an emergency light in the event of power loss.

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700.16 Emergency Illumination, Part 2.

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Example:

The circuit breaker for this emergency luminaire is switched off and the fixture is running on battery power during final inspection.

This job failed the final inspection but would have passed if the emergency light was properly arranged so that the failure of one lamp would not leave this space in total darkness.

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Final Inspection - 110.3(B) Installation and Use.

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2023 National Electrical Code (NEC)[®]

Article 110 General Requirements for Electrical Installations

110.3 Examination, Identification, Installation, Use, and Listing (Product Certification) of Equipment.

(B) Installation and Use. Equipment that is listed, labeled, or both, or identified for a use shall be installed and used in accordance with any instructions included in the listing, or-labeling, or identification.

Informational Note: The installation and use instructions may be provided in the form of printed material, quick response (QR) code, or the address on the internet where users can download the required instructions.

Exterior emergency lights are often needed outside exit doors, which could be considered a wet or a damp location depending on exposure.

COURSE TITLE

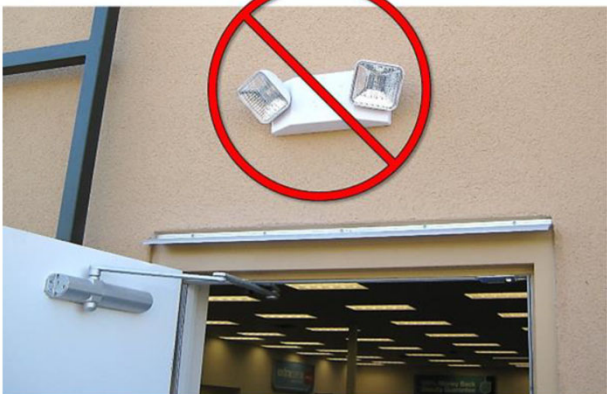
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110.3(B) Installation and Use.

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Dry location emergency luminaires cannot be installed outside in wet locations.

1103(B) is updated for 2023 to add the industry term “identified for use,” with a new informational note that reflects the increased online availability of instructions for installation and use.

COURSE TITLE

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427.22 Pipelines and Vessels; Ground-Fault Protection of Equipment.

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2023 National Electrical Code (NEC)[®]

Article 427 Fixed Electric Heating Equipment for Pipelines and Vessels

427.22 Ground-Fault Protection of Equipment. Ground-fault protection of equipment shall be provided for electric heat tracing and heating panels. This requirement shall not apply in industrial establishments where there is alarm indication of ground faults and the following conditions apply:

(1) Conditions of maintenance and supervision ensure that only qualified persons service the installed systems.

(2) Continued circuit operation is necessary for safe operation of equipment or processes.

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427.22 Pipelines and Vessels; Ground-Fault Protection of Equipment.

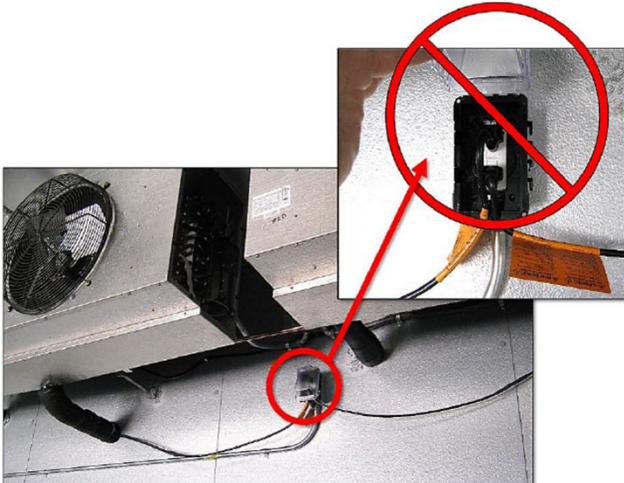
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427.22 requires GFPE for heat tracing lines.

These are often installed on the condensate line in walk-in freezers to ensure that the condensate line does not freeze.

GFPE is defined as:
A system intended to provide protection of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit.



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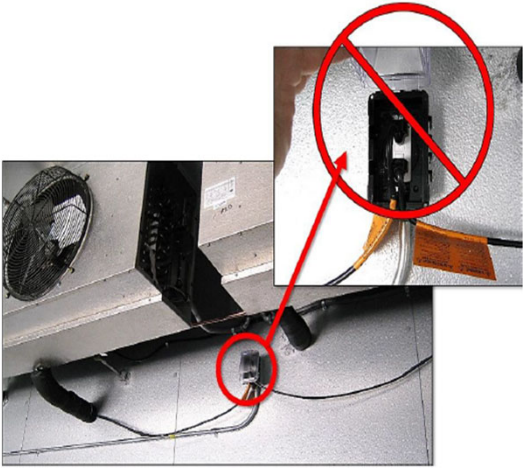
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427.22 Pipelines and Vessels; Ground-Fault Protection of Equipment.

Using a GFCI device to protect the heat trace line instead of GFPE can cause nuisance tripping at low current levels, which is harmless to the equipment being protected.

The most common method to provide GFPE is a circuit breaker supplying the heat tracing line.

Simply installing a GFCI-type receptacle in the freezer does not comply with the intent of Section 427.22.



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Final Equipment Installation.

When final inspection is requested by the contractor, all electrical work should be done with no work remaining.

- Plans are approved by the city plans examiner.
- Plans are recorded and accessed in the future if litigation occurs.
- If equipment has not yet been installed, the electrical contractor should obtain a separate permit.
- Electrical wiring for the equipment can be inspected later; the main permit for final occupancy can be closed.



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All final equipment shown on the city-approved plans must be installed for the final inspection to be approved

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Final Equipment Installation.

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- A temporary certificate of occupancy can be given if there are no life-safety related items or Code violations that need correction.
- An electrical inspector who passes the job for final when there are still uninstalled/missing items or equipment shown on the plans bears the responsibility in the courtroom if inadequate wiring methods to these items cause injury to a patron.



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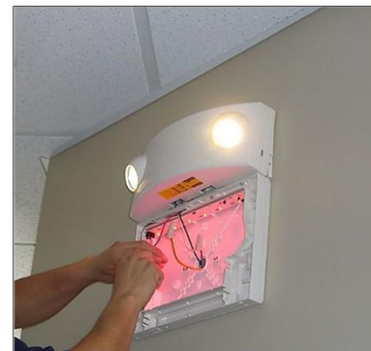
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700.12(H)(2)(3) Battery Equipped Emergency Luminaires.

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**Significant changes to Article 700 for 2023.*

- All battery powered luminaires must be LISTED.
- Emergency luminaires must be fixed in place.
- Flexible cord-and-plug connection shall be permitted for unit equipment, provided that the cord does not exceed 3 ft in length.
- Flexible cord, with or without a plug, is permitted for battery-equipped emergency luminaires installed in accordance with 410.62(C)(1).



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700.11 Identification of Emergency Lighting Circuits.

Emergency lighting and exit signs (unit equipment) are required to be clearly identified in the panelboard that supplies them. Properly identifying these circuits ensures that they will remain energized and fully charged at all times.

Panel Wiring Schedule (3-Phase)

Panelboard
Panel Type
NEMA Type

"LPA"

1

Voltage
OCPO
Mounting

208Y/120
M.L.O.
SURFACE

Ckt. No.	Zone	Load Description	Brkr. Size	Brkr. Opts.	N.E.C. kVA	Phase
1	EM	FD1 - LEFT SIDE LTS			0.900	A
3	EM	FD1 - LEFT SIDE LTS			0.900	B
5	EM	FD1 - LEFT SIDE LTS			0.900	C
7	EM	FD1 - LEFT SIDE LTS			0.900	A
9		LFB/LFC - RIGHT SIDE LTS			0.420	B
11		RH/RHC - OUTER LTS			0.240	C
13		RH/RHC - RIGHT SIDE LTS			0.390	A
15	EM	BOH LOWER LTS			1.040	B
17		SPARE			0.000	C
19	EM	NIGHT LIGHTS			0.360	A
21		SPARE			0.000	B
23		INSTA-HOT		PA	0.000	C

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700.11 Identification of Emergency Lighting Circuits.

(B) Identification

1. All boxes and enclosures for Class 2 emergency circuits shall be permanently marked as a component of an emergency circuit or system.

2. Exposed cable, cable tray, or raceway systems shall be permanently marked to be identified as a component of an emergency circuit or system, within 900 mm (3 ft) of each connector and at intervals not to exceed 7.6 m (25 ft).

Panel Wiring Schedule (3-Phase)

Panelboard
Panel Type
NEMA Type

"LPA"

1

Voltage
OCPO
Mounting

208Y/120
M.L.O.
SURFACE

Phase
Wire
Bus

3
4
125A

Options/Notes
AFC Rating

22,000

Ckt. No.	Zone	Load Description	Brkr. Size	Brkr. Opts.	N.E.C. kVA	Phase	N.E.C. kVA	Brkr. Opts.	Brkr. Size	Load Description	Zone	Ckt. No.
1	EM	FD1 - LEFT SIDE LTS			0.900	A	0.900			FD1 - RIGHT SIDE LTS	EM	2
3	EM	FD1 - LEFT SIDE LTS			0.900	B	0.900			FD1 - RIGHT SIDE LTS	EM	4
5	EM	FD1 - LEFT SIDE LTS			0.900	C	0.900			FD1 - RIGHT SIDE LTS	EM	6
7	EM	FD1 - LEFT SIDE LTS			0.900	A	0.900			FD1 - RIGHT SIDE LTS	EM	8
9		LFB/LFC - RIGHT SIDE LTS			0.420	B	0.540			LFB/LFC - LEFT/MIDDLE LTS	EM	10
11		RH/RHC - OUTER LTS			0.240	C	0.840			BOH UPPER LTS	EM	12
13		RH/RHC - RIGHT SIDE LTS			0.390	A	0.120			RH/A - STOREFRONT LTS	EM	14
15	EM	BOH LOWER LTS			1.040	B	0.270			RH/RHC - CENTER LTS	EM	16
17		SPARE			0.000	C	1.200			STOREFRONT SIGNAGE		18
19	EM	NIGHT LIGHTS			0.360	A	0.000			SPARE		20
21		SPARE			0.000	B	0.250			RH/B - LEFT SIDE/HALL LTS		22
23		INSTA-HOT		PA	0.000	C	0.000	LO		FIRE ALARM CRT'L PANEL		24

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700.11 Identification of Emergency Lighting Circuits.



(C) Separation of Circuits
Class 2 emergency circuits
wired in a listed, jacketed cable
or with one of the wiring
methods in **Chapter 3**

Alongside nonemergency
Class 2 circuits that are
bundled, Class 2 emergency
circuits are bundled separately

Panel Wiring Schedule (3-Phase)						
Panelboard	"LPA"		Voltage	208Y/120		
Panel Type			OCBD	M.L.O.		
NEMA Type	1		Mounting	SURFACE		
Ckt. No.	Zone	Load Description	Brkr. Size	Brkr. Opts.	N.E.C. kVA **	Phase
1	EM	FD1 - LEFT SIDE LTS			0.900	A
3	EM	FD1 - LEFT SIDE LTS			0.900	B
5	EM	FD1 - LEFT SIDE LTS			0.900	C
7	EM	FD1 - LEFT SIDE LTS			0.900	A
9		LFB/LFC - RIGHT SIDE LTS			0.420	B
11		RHA/RHC - OUTER LTS			0.240	C
13		RHB - RIGHT SIDE LTS			0.390	A
15	EM	JOH LOWER LTS			1.040	B
17		SPARE			0.000	C
19	EM	NIGHT LIGHTS			0.360	A
21		SPARE			0.000	B
23		INSTA-HOT		PA	0.000	C

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210.8 GFCI Protection for Personnel.



- Changes to NEC 210.8(A)
- Outlets that serve food and beverage preparation areas must now be GFCI protected even if there is no sink within 6 feet
 - A listed Class A GFCI provides protection
- [210.8(A) through (F)]



GFCI protection is required for all 15 or 20-ampere, 125-volt, single phase bathroom receptacles.

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210.8 GFCI Protection for Personnel.

Other Than Dwelling Units

- (1) Bathrooms
- (2) Garages and accessory buildings with floor located at or below grade level
- (3) Outdoors
- (4) Crawl spaces — at or below grade level
- (5) Basements
- (6) Kitchens
- (7) Areas with sinks and permanent provisions for food preparation, beverage preparation, or cooking

**Refer to handbook*



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210.8 GFCI Protection for Personnel.

Required to have GFCI protection whether cord-and-plug connected or hard wired:

- kitchen dishwasher outlets
- vending machines
- electric drinking fountains
- tire inflation machines and automotive vacuum machines provided for public use
- floor heating cables
- most underwater pool luminaires
- spas and hot tubs
- single phase, 120–240-volt pool pump motors



Note that there are four exceptions to the rules.

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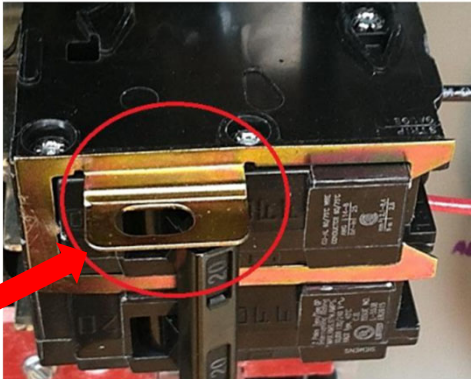
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110.25 Lockable Disconnecting Means.

- The inspector verifies lockable or lock-on devices at the panelboard.

Non-motor appliance (e.g., water heater or cooktop) not required to have a disconnecting means within sight of the appliance if the circuit breaker supplying it is lockable

- To lock the circuit breaker or switch in open position must be part of the enclosure or accessory that’s not readily removed from the circuit breaker or switch.



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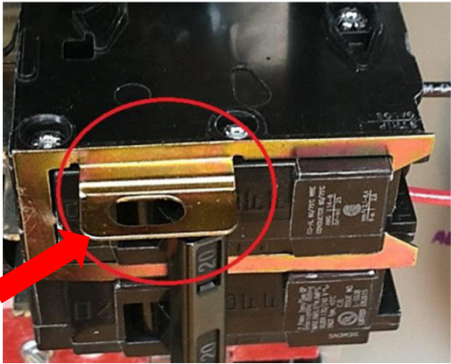
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110.25 Lockable Disconnecting Means.

- The fire inspector may require lock-on devices for fire alarm panel circuits.

Purpose: ensures circuit remains energized for safety

- Circuit breakers are required to be able to interrupt a fault condition regardless of switch handle position.



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Example of a lockable device

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