Installation Checklists (Homestudy)

Virginia Electrical License

This course will focus on the key points that electrical inspectors look for when making commercial or residential inspections. The course provides important installation practices for passing a rough and final inspection. Also included are NEC requirements for installing wiring underground, above the ceiling, and on the rooftop. Checklist items cover installing and grounding panelboards, services, and transformers.

Course# 2731002702   3 Code Credit Hours $50.00

This course is currently approved by the Virginia Department of Professional and Occupational Regulation under course number 2731002702.

Completion of this continuing education course will satisfy 3.000 credit hours of course credit type 'Code' for Electrical license renewal in the state of Virginia. Course credit type 'Code'. Board issued approval date: 5/19/2016. Board issued expiration date: 5/19/2020. .

JADE Learning's provider number from the Virginia DPOR is 2730000095.

Installation Checklists (Homestudy) - VA

Underground

Question 1: 300.5(F) Backfill.

Question ID#: 10333.0

For an underground installation, there is more to it than just getting the correct burial depth and minimum cover requirements right. Using the right backfill materials is just as important.

Backfill over raceways and cables cannot contain large rocks.

Backfill cannot contain:

- Large rocks
- Paving materials
- Cinders
- Large or sharply angular substances
- Corrosive material

Section 300.5(F): ***Where necessary to prevent physical damage to the raceway or cable, protection shall be provided in the form of granular or selected material, suitable running boards, suitable sleeves, or other approved means***.

In areas where backfill is known to be an issue because of rocky soil conditions, it is quite common for the inspection department to require an additional shading inspection after a trench is approved to cover. Bedding and shading the wiring method with 6 in. to 12 in. of sand, before the poor quality backfill that initially came out of the trench is dumped back in, will ensure proper protection for the wiring methods.

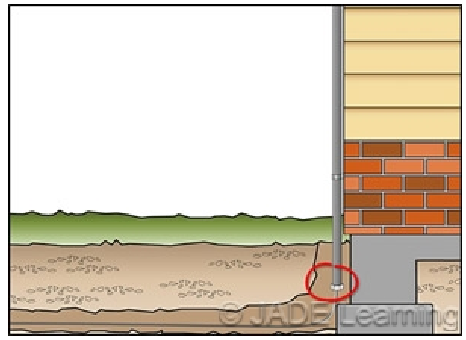
Question 1: Which of the following can be used as a form of protection for a cable in a trench where poor backfill materials are an issue?

A: Suitable sleeves.
B: Sharp gravel.
C: River rock.
D: Broken pieces of asphalt.

Question 2: 300.5(H) Bushings.

Question ID#: 10334.0

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.



Bushings are required at the end of a raceway terminating underground.

Direct buried cables are installed underground but must emerge at some point. Section 300.5(D)(1) requires protection for these cables from the minimum burial depth up to 8 ft. above finished grade. This protection can be in the form of an enclosure or raceway, but nothing is mentioned in this section about damage that can occur where the cable enters the raceway from the underground trench.

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

Question 2: Which of the following is the correct way to transition from an underground cable into a raceway installed for protection from physical damage?

A: Straight into threaded rigid conduit.
B: Into a metal raceway that has been cut with a pipe cutter.
C: Straight into an EMT raceway.
D: Through a bushing on the raceway.

Question 3: 300.5(J) Earth Movement.

Question ID#: 10335.0

Expansion, contraction, earth settling, and frost heaves can create a nightmare for underground conductors or raceways. Compensating for these conditions will ensure the wiring methods will not pull away from the terminals or pull equipment off the wall.

Consideration should be given to possible expansion or contraction or earth settling after an installation.

Section 300.5(J) requires direct-buried conductors, raceways, and cables subject to movement by settlement or frost, to be arranged so as to prevent damage to the enclosed conductors or the equipment connected to the raceways. These conditions should be considered whether the installation is a service raceway, feeder raceway to an outbuilding, or branch circuit wiring method. Many utility companies have specific requirements, not mentioned in the NEC, on proper installation of underground service raceways into a meter base. If these are not followed, the utility company will refuse to make the final power connection and set a meter.

The informational note mentions techniques like "S" loops in underground direct-buried cables, expansion fittings in raceway risers, and flexible connections to equipment that is subject to settlement or frost heaves.

Question 3: Which of the following is a good practice to account for earth settling that can occur?

A: A PVC conduit emerging from grade and connecting directly to the bottom of an outdoor panelboard.
B: An expansion fitting in a 2 in. PVC raceway after it emerges from grade to supply an outdoor subpanel.
C: Not securing an outdoor panelboard to the wall so that it can move freely as needed.
D: A direct-buried cable, with plenty of slack, exposed and emerging from grade without a raceway before it connects directly to an outdoor panelboard.

Question 4: Table 300.5 Minimum Cover Distance.

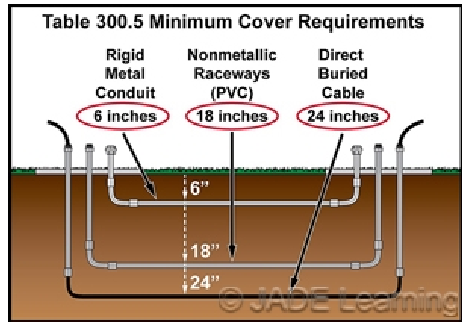
Question ID#: 10336.0

Table 300.5 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.

Cover distance is not the same as trench depth. In order to get the correct cover distance over the top of an underground wiring method, the trench will need to be deeper than the minimum cover distance shown in the table.

The table covers installations from 0 to 1000 volts which can include empty spare raceways and low voltage wiring methods unless specifically modified in Chapters 7 and 8 of the NEC.

The illustration shows general cover distances based on commonly used wiring methods. The image does not show every possible unique circumstance or situation. Refer to NEC Table 300.5 for specific cover distances when raceways might be under a building, under a driveway, under 2 inches of concrete, etc.



General measurements for exterior wiring methods.

Question 4: What is the minimum cover distance for a 2 in. rigid PVC conduit, installed outdoors under a football field to serve field lighting?

A: 6 in.
B: 12 in.
C: 18 in.
D: 24 in.

Question 5: 300.5(G) Raceway Seals.

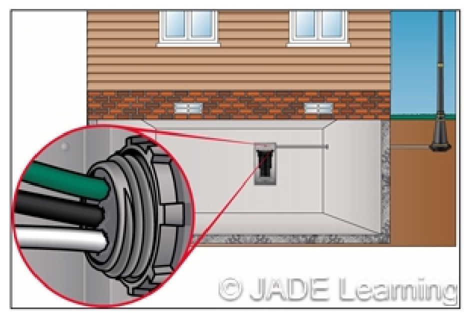
Question ID#: 10337.0

Conduits or raceways through which moisture may contact live parts shall be sealed or plugged at either or both ends. Conduits installed underground will always fill with water. Sealing the ends of the conduit will keep the water out.

The NEC actually only requires a seal at one end of the conduit run but permits both ends to be plugged. It is important to remember that the rules in the NEC are MINIMUM requirements, and there is nothing that prohibits installing above the minimum. In a long run of underground conduit, it is better to plug both ends just to be sure that moisture from condensation or wet soil conditions will not enter the raceway and find its way into a panelboard or other interior location where water is not wanted.

Another way to avoid water migration from an underground raceway to the inside of a panelboard enclosure is to arrange the raceway entry into the panelboard beneath any energized components. The illustration shows a raceway entering above the energized components but it is sealed to ensure moisture cannot contact live parts in the enclosure.

Section 300.5(G) is silent on what material should be used to seal or plug the end of a conduit, but Section 225.27 has similar requirements for outside feeders or branch circuits entering a building. That section states that ***sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components.***



Raceway sealed to ensure moisture does not contact live parts.

Question 5: What does the NEC require for an underground raceway entering an enclosure above energized components?

A: It must be rigid metal conduit.
B: It must be rerouted to enter below energized components.
C: Both ends must always be sealed.

D: At least one end must be sealed.

Question 6: 314.27(B) Floor Boxes.

Question ID#: 10338.0

Only boxes listed specifically for a floor installation are permitted to be used for receptacles located in the floor.

Before the concrete slab is poured, all too often, an inspector will arrive to find standard galvanized four square metal boxes wrapped in duct tape and installed as floor boxes for receptacles. The NEC makes it clear that receptacles installed in the floor must be installed in boxes listed for the application.

The exception to Section 314.27(B) gives a bit of wiggle room for the inspector. ***Where the authority having jurisdiction judges them free from likely exposure to physical damage, moisture, and dirt, boxes located in elevated floors of show windows and similar locations shall be permitted to be other than those listed for floor applications. Receptacles and covers shall be listed as an assembly for this type of location.***

Listed floor boxes and listed receptacle/cover assembly.

In order to apply the exception and use a box not listed for floor applications, two things must occur:

- The AHJ must feel that the box is not subject to physical damage, moisture, or dirt.
- The box must be installed in the elevated floor area of a show window or similar location.

Even if the exception is allowed and a standard box is installed, the last sentence in the exception still requires the receptacles and covers used in the box to be listed as an assembly for the type of location.

Question 6: Which of the following can be used for a floor receptacle installed in the center of a conference room?

A: Any standard device box.
B: A box listed specifically for floor installations.
C: Any box that provides protection against corrosion.
D: A two-gang plastic nail-on box.

Question 7: 250.52(A)(3) Concrete-Encased Electrode.

Question ID#: 10339.0

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

Buildings supplied with an alternating current electrical service must have a grounding electrode conductor connected to a grounding electrode. Concrete-encased electrodes are one of several types of grounding electrodes and are often used when rebar is installed in concrete footings that will be poured directly against the earth. If a vinyl, polyethylene, or any other vapor barrier is installed that isolates the footing from direct earth contact, then a true concrete-encased electrode does not actually exist and another type of electrode must be used.

According to 250.52(A)(3), a concrete-encased electrode shall consist of either of the following two items:

- At least 20 ft. of rebar, no smaller than 1/2 in. (can be several pieces joined by welding or steel tie wire).
- At least 20 ft. of bare copper conductor no smaller than 4 AWG.

The concrete-encased electrode must meet the following requirements:

- It must have no less than 2 in. of concrete encasement.
- It must be located horizontally within that portion of a concrete foundation or footing in direct contact with the earth or within vertical foundations or structural components or members in direct contact with the earth.
- If multiple concrete-encased electrodes are present at a building or structure, only one must be bonded to the grounding electrode system.

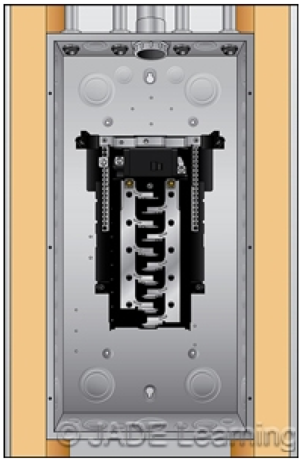
Question 7: If a concrete-encased electrode is to be used, which of the following applies?

A: It must have at least 4 inches of concrete encasement.
B: An insulated conductor can be used.
C: The concrete encasement around the electrode must have direct earth contact.
D: If rebar is used, it must be one continuous length without a splice.

Rough Inspection

Question 8: Rough Inspection Basics.

Question ID#: 10341.0



Rough inspection is scheduled after all electrical raceways and cables that will be concealed from view have been installed but before they are covered.

For houses and small commercial projects, the inspector will want all wiring methods, cables, and enclosures in walls and ceilings to be completed, inspected, and approved before insulation or sheetrock can be installed. On larger projects, the inspector will come out as needed to approve the rough inspection in phases in order to keep the job moving. Generally, the inspector will approve portions of walls and ceilings that are ready for inspection and mark the city approved plans in the jobsite trailer so that all trades are aware of what has been approved to cover.

Quite often, a contractor might schedule an inspection of all rough wall electrical but the panelboard might not yet be installed. It's important for the inspector to see the home run raceways or cables into the panel after they are installed but before they are covered. If special allowances are being made, such as the inspector giving the ok to one-side the walls with sheetrock before performing the rough inspection, or giving approval on all walls except the wall where the panel is yet to be installed, then documentation is key.

Another inspector filling in for the original inspector who is out sick creates problems if special allowances were made and no one has documentation of it.

International Residential Code (IRC) R109.1.2: Rough inspection of plumbing, mechanical, gas and electrical systems shall be made prior to covering or concealment, before fixtures or appliances are set or installed, and prior to framing inspection.

International Building Code 110.3.4: Framing inspections shall be made after the roof deck or sheathing, all framing, fireblocking and bracing are in place and pipes, chimneys and vents to be concealed are complete and the rough electrical, plumbing, heating wires, pipes and ducts are approved.

Question 8: When does the rough inspection take place?

A: Before the walls are framed.
B: After the wiring methods and insulation are installed in the walls.
C: After the wiring methods are installed but before the walls are insulated.
D: After all walls are sheetrocked.

Question 9: 517.13(A) Branch Circuits Serving Patient Care Areas.

Question ID#: 10342.0

Healthcare grade MC cable installed at a medical facility to serve patient care areas.

Patients in health care facilities are often connected to electro-medical equipment for testing, dialysis, x-ray, life support, and the like. When instruments are connected to the patient, there is an increased risk of possible conductive pathways from grounded objects to a patient. Conductive surfaces or instruments that make contact with the patient become possible sources of electric currents that can traverse the patientâ€™s body. The hazard is increased as more devices are connected to the patient, and, therefore, more intensive precautions are needed.

Having a redundant grounding system in patient care areas helps insure that a ground fault will not be fatal to a patient that is hooked up to medical equipment.

Section 517.13(A) requires the branch circuits used in patient care areas to be provided with an ***effective ground-fault current path*** by installation in a metal raceway system, or a cable having a metallic armor or sheath assembly. Section 517.13(B) requires an insulated equipment grounding conductor to be in the cable or raceway. The combination of the metal raceway and the equipment grounding conductor pulled through the raceway creates redundant equipment grounding paths in the event that one was not an effective path.

Article 100 defines an effectiveground-fault current path as ***an intentionally constructed, low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions.***

Section 517.13(A) states: ***The metal raceway system, or metallic cable armor, or sheath assembly shall itself qualify as an equipment grounding conductor in accordance with 250.118***.

The most commonly used branch circuit wiring methods that comply with 517.13(A) and that qualify as an equipment grounding conductor according to 250.118 are:

- Intermediate metal conduit
- Rigid metal conduit
- Electrical metallic tubing
- Type AC cable
- Listed healthcare grade MC cables

The most commonly installed branch circuit wiring methods that VIOLATE Section 517.13(A) are:

- Standard MC cables
- Flexible metal conduit
- Liquidtight flexible metal conduit

Question 9: Which of the following wiring methods can be used to wire receptacles serving a patient care area in a hospital?

A: Electrical metallic tubing.
B: Flexible metal conduit.
C: Liquidtight flexible metal conduit.
D: Standard MC cable.

Question 10: 110.12(A) Unused Openings.

Question ID#: 10343.0

Unused openings must be sealed.

Section 110.12(A): ***Unused openings, other than those intended for the operation of equipment, those intended for mounting purposes, or those permitted as part of the design for listed equipment, shall be closed to afford protection substantially equivalent to the wall of the equipment***.

Unused openings can include:

- Missing knockouts in panelboards, metal and plastic boxes
- Abandoned openings in plastic boxes through which a cable was removed
- Box covers for power and data.

Sealing unused openings ensures the containment of possible arcs or sparks to within the electrical enclosure. Mounting holes provided by the manufacturer are not subject to this requirement. The inspector will be verifying compliance with this section during the rough, above ceiling, and final inspections.

Question 10: Which of the following unused openings must be closed?

A: Mounting holes in the back of a panelboard.
B: An empty hole for a ground screw if a ground clip was used instead.
C: A 1/2 in. knockout where an MC cable connector was removed.
D: Manufacturer provided drain holes.

Question 11: 330.30 MC Cable. Securing and Supporting.

Question ID#: 10344.0

Healthcare grade MC cable installed in patient care areas of a health care facility.

Type MC Cable is commonly used in many commercial buildings because it's easy to install and can be used for many applications. MC Cable is not usually used in residential construction because cheaper wiring methods such as Type NM (Nonmetallic-Sheathed Cable) are available.

There are many different types of buildings using different construction methods permitted in the Building Code. The type of construction will determine what wiring methods are permitted to be installed. If the building is being constructed as a type 1 or 2 (noncombustible), then metallic wiring methods such as MC Cable are often used because of the metal corrugated noncombustible jacket.

Running MC Cable is fast and easy but it must be secured properly and supported at the correct intervals in accordance with Section 330.30. There is a difference between securing and supporting so the code sections below require a careful read:

- ***330.30(A) General:*** MC cable must be supported and secured by staples, cable ties, straps, hangers, or similar fittings that will not damage the cable.
- ***330.30(B) Securing:*** MC cables containing four or fewer conductors size No. 10 AWG or smaller must be secured within 12 in. of every box, cabinet, fitting, or other cable termination. MC cables containing conductors larger than No. 10 AWG are not required to be secured within 12 inches of the outlet box. MC cables must be secured every 6 ft. For vertical installations, listed cables with ungrounded conductors size 250 kcmil and larger can be secured every 10 ft.
- ***330.30(C) Supporting:*** MC cable must be supported every 6 ft. A horizontal run of MC cable through framing members is considered secured and supported as long as the framing members are not greater than 6 ft. apart.

An MC cable can be ***secured*** with a strap within 12 inches of a box. An MC cable is ***supported*** if run through studs that are not more than 6 ft. apart.

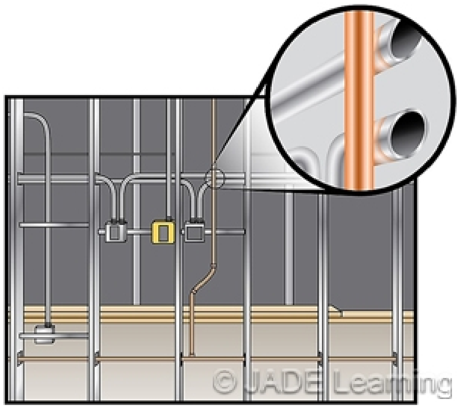
See 330.30(D) for installations that would allow an MC cable to remain unsupported.

Question 11: What is the maximum distance from an outlet box that an MC cable with No. 12 AWG conductors must be secured?

A: 12 in.
B: 24 in.
C: 30 in.
D: 6 ft.

Question 12: 342.14, 344.14, and 358.12(6). Dissimilar Metals.

Question ID#: 10345.0



Dissimilar metals must be separated.

Galvanic action can occur if two dissimilar metals come in contact with one another. This creates a conductive path for ions and electrons to transfer and deposit from one surface to the other. This is when corrosion begins. On most job sites, the most common culprit will be the copper water lines or air conditioning lines installed by plumbers and HVAC technicians. It can be frustrating to install steel electrical raceways in an open wall and then have a rough inspection turned down because the plumber came in and installed water lines right up against the electrical raceways after the electrician left.

The NEC makes mention of dissimilar metals and requires proper raceway separation from a dissimilar surface in 3 code sections.

- Section 342.14 Intermediate Metal Conduit
- Section 344.14 Rigid Metal Conduit
- Section 358.12(6) Electrical Metallic Tubing

The following code language is present in all three of the above sections:

Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

Even though the NEC does not specifically require the separation for Type AC or MC Cables, many inspectors will still ask for some kind of separation from copper lines since these wiring methods have a metal jacket made of steel or aluminum. Often the separation can be as simple as 20 mil black tape which is commonly used for additional protection of metal raceways installed in corrosive soil conditions.

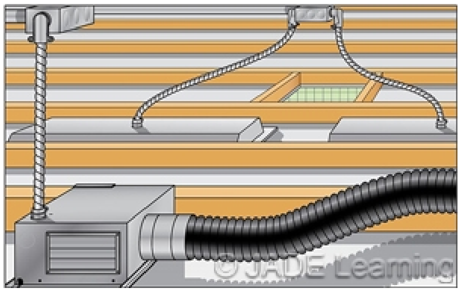
Question 12: Electrical Metallic Tubing and copper water lines should be separated from all possible contact in order to avoid _____________.

A: Biodegradation.
B: Combustion.
C: Galvanic action.
D: Decomposition.

Question 13: Article 100 Definitions. Accessible.

Question ID#: 10346.0

Article 100 Accessible (as applied to wiring methods): Capable of being removed or exposed without damaging the building structure or finish or not permanently closed in by the structure or finish of the building.



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.

In building construction, there can be many different ways to enclose a ceiling. On some projects, bathroom ceilings will be no different than other suspended grid ceilings in adjacent areas. On other projects, the owner might want all bathroom ceilings to be framed and sheetrocked so that there is no ceiling tile providing access for a person to crawl across a ceiling to get from one bathroom to another. It is important to know how these areas can be accessed before roughing in electrical boxes or other things that the NEC requires to be accessible.

Examples of items required to be accessible in the NEC are:

- Box covers, 300.15(A)
- Wiring inside boxes, 314.29
- Grounding electrode conductor taps for multiple separately derived systems, 250.30(A)(6)

- Bonding clamps to water pipes, exposed structural steel, gas pipes, etc., 250.104
- Cable trays, 392.18(E).

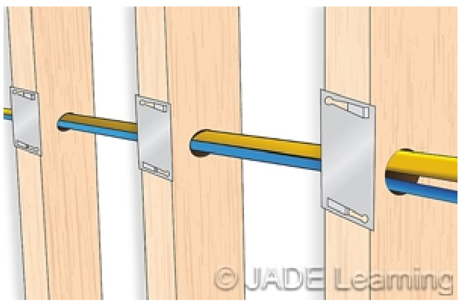
Strategically placing the above items in locations that can be easily reached through a suspended ceiling tile is key. If not, be ready to cut a permanent access door into the ceiling or prove to the inspector that the items above can be reached without removing or damaging the building finish.

Question 13: Which of the following is accessible?

A: A box cover that can only be accessed by removing floor boards.
B: Wiring in a box that can only be accessed by removing exterior wall materials.
C: A concealed box cover in a wall that the sheetrock installer forgot to cut around and expose.
D: A junction box above a suspended ceiling.

Question 14: 300.4(A)(1) Cables and Raceways Through Wood Members. Bored Holes.

Question ID#: 10347.0



Cables installed through bored holes 1 1/4 in. from nearest edge of stud must have nail protection.

Where cables or raceways (other than RMC, IMC, RNC and EMT) are installed through bored holes, the hole must be drilled so that the closest edge of the hole is at least 1 1/4 in. from the nearest edge of the stud, joist, or rafter. If this distance cannot be achieved, the wiring method must be protected from possible nail or screw penetration. Nail protection for these wiring methods must be a steel plate at least 1/16 in. thick and of appropriate length and width to cover the area of the wiring. Other nail plates that may be less than 1/16 in. thick are also permitted if they have been ***listed*** and marked.

When the NEC speaks of bored holes through wood members, the rules apply whether the wood member being drilled is a wall stud, floor/ceiling rafter, or floor/ceiling joist. The NEC speaks about protecting the wiring method in the hole but the Building Code specifies where the hole can be drilled and how big the hole can be. For example, IBC 2308.4.2.4 states that a hole through a joist cannot be within 2 in. of the top or bottom of the joist and the hole diameter cannot exceed 1/3 the joist depth.

Think twice before drilling engineered wood products such as glulam (glued laminated) beams or TJI's (truss joist I) beams. These products are specified where certain spans and strengths are required and are used where they will be stressed under specific design loads. Any field drilling of these products must be done only in locations on the beam where they will not compromise the integrity of the beam. Field drilled holes must be done in accordance with the manufacturer guidelines.

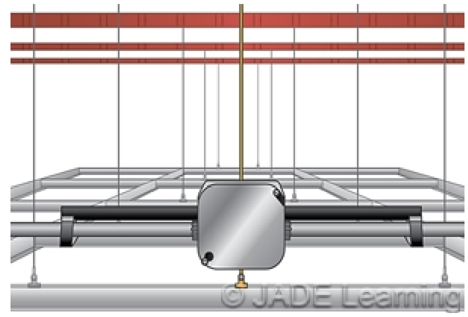
Question 14: How can a cable installed through a wood member be protected from nail or screw penetration?

A: A 1/16 in. steel nail plate.
B: A steel structural strap that covers a lap joint in the double top plate of a wall.
C: Installing Metal Clad, Type MC cable, with a metal jacket.
D: Installing Armored Cable, Type AC, with a metal jacket.

Above the Ceiling

Question 15: 300.11(A) Secured in Place.

Question ID#: 10349.0



Support wires for junction boxes and wiring methods must be independent of those used to support the ceiling and must be identified by color or tagging.

Raceways, cable assemblies, boxes, cabinets, and fittings must be securely fastened in place. Finding ways to support wiring methods and boxes above a suspended ceiling often requires a creative approach.

Section 300.11(A) makes it clear that support wires that do not provide secure support cannot be the only support. The only support wires that can be used to secure wiring methods and boxes are those that are NOT specifically there to hold up the suspended ceiling grid.

The support wires that do hold up the ceiling grid are easily recognized. The ASTM standard for ceiling grid systems require a support wire on the main T-bar runner within 8 inches of the wall and every 4 ft. thereafter for 12 gauge support wires and every 5 ft. for 10 gauge support wires. The ceiling support wires must be looped through a hole in the grid and then twisted tightly with at least three full wraps within the first 3 inches above the T-bar. Simply put, do not use the support wires described above as a means of support for wiring methods.

Section 300.11(A) also states the following:

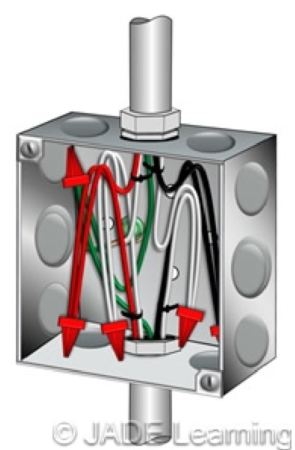
- Where independent support wires are used, they shall be secured at both ends.
- Cables and raceways shall not be supported by ceiling grids.
- Where independent support wires are used, they shall be distinguishable by color, tagging, or other effective means.

Question 15: Which of the following support wires can be used above a suspended ceiling to secure a metal raceway?

A: A support wire installed by the electrician that does NOT provide secure support.
B: A support wire, secured at one end, and painted green, that was installed by the electrician.
C: An existing support wire that holds up the ceiling.
D: A support wire, secured at both ends, and painted blue, that was installed by the electrician.

Question 16: 200.4 Multiple Circuits.

Question ID#: 10350.0



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

When multiple neutral conductors, associated with different circuits, are present in any enclosure, the neutrals must be identified or grouped with their associated ungrounded conductors. The identification or grouping must occur in at least one location within the enclosure and can be done with wire markers, cable ties, or similar means.

The intent is simple. The basic idea is to always make sure that it is easy to tell which neutral goes with which ungrounded conductor in the box. Knowing which circuit is completed by a specific neutral makes troubleshooting and maintenance much safer. Opening a neutral conductor under load by mistake can be just as dangerous as pulling the wire nut off a live phase conductor.

Neutral conductors are not generally allowed to be switched like ungrounded conductors through overcurrent devices or other switches. The byproduct of this is a situation where neutral conductors can only be disconnected for troubleshooting by pulling off the wire splice or removing the neutral from a busbar. Without this grouping requirement, every time a neutral is disconnected, it's a roll of the dice to see if the correct neutral was chosen from a deenergized circuit or if a bad choice was made and the wrong neutral was opened under load.

The exceptions to this rule allow neutral conductors to remain ungrouped for the following:

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

Question 16: Which of the following installations requires the neutrals to be grouped with their associated ungrounded circuit conductors?

A: All circuits enter from a raceway, and there is more than one neutral and more than one circuit in the box.
B: There is only a single, 2-wire circuit in a box.
C: A circuit containing the neutral enters the box from an MC cable.
D: A circuit containing the neutral enters the box from an AC cable.

Question 17: 424.66(B) Duct Heaters with Limited Access Above Ceiling.

Question ID#: 10351.0

Section 424.66(B) requires working space for duct heaters with limited access above ceiling. ***Sufficient clearance shall be maintained to permit replacement of controls and heating elements and for adjusting and cleaning of controls and other parts requiring such attention. See 110.26***. Even without reading further into the Code section, it is already clear that working space, similar to that required for panelboards or other equipment likely to be examined while energized, is required.

Working space is required above ceiling at duct heaters.

For limited access installations, such as the area above a suspended ceiling, section 424.66(B) requires the following:

(1) The enclosure shall be accessible through a lay-in type ceiling or an access panel(s).

(2) The width of the working space shall be the width of the enclosure or a minimum of 762 mm (30 in.), whichever is greater.

(3) All doors or hinged panels shall open to at least 90 degrees.

(4) The space in front of the enclosure shall comply with the depth requirements of Table 110.26(A)(1). A horizontal ceiling T-bar shall be permitted in this space.

Other codes such as the International Mechanical Code, have similar requirements:

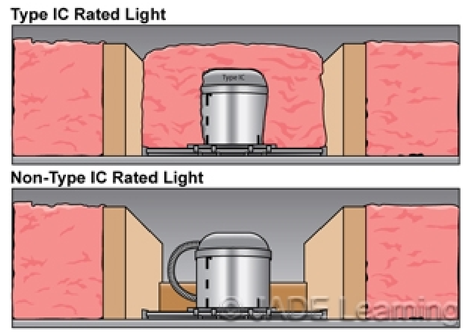
IMC 306.1 Access: A level working space not less than 30 inches deep and 30 inches wide shall be provided in front of the control side to service an appliance.

Question 17: Working space above a ceiling for a 20 in. wide duct heater must be at least _____.

A: 36 in.
B: 20 in.
C: 30 in.
D: 42 in.

Question 18: 410.116 Clearance and Installation.

Question ID#: 10352.0



Clearances from a Type IC luminaire to combustible framing and thermal insulation differ from that of a Non-Type IC luminaire.

Some recessed luminaires are rated for insulation contact (IC) while others are not. Part of the listing process for luminaires requires IC-rated fixtures to be marked "TYPE IC," or "INHERENTLY PROTECTED". According to the ***Luminaire Marking Guide*** in the ***UL White Book***, Type IC luminaires may be installed where thermal insulation is placed in direct contact with the sides and top of the luminaire. They are protected against overheating by either thermal protection, or they are inherently protected. Inherently protected luminaires are designed so that overheating conditions cannot be caused by overlamping or mislamping the luminaire.

For Non-Type IC recessed luminaires, NEC Section 410.116(A) requires at least 1/2 inch clearance from the fixture to combustible materials and at least 3 inch clearance from insulation to any part of the luminaire. Recessed Type IC luminaires can be in full contact with combustible materials and insulation.

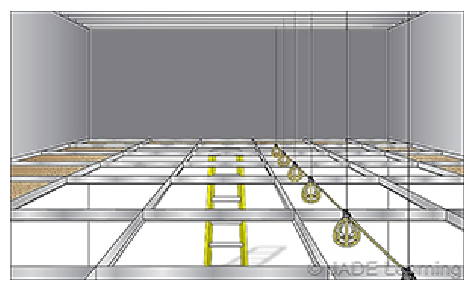
Some recessed luminaires can be used as either Type IC or Non-Type IC. These are considered "convertible" recessed luminaires.When a convertible luminaire is created, the same luminaire housing is used for both Type IC and Non-Type IC applications. The combination of the trim and light source determine the Type IC or Non-Type IC application of the luminaire.Installation instructions are provided with the luminaire that require the installer to remove the marking label relating to proper spacing to thermal installation when the luminaire is installed to be used as a Type IC luminaire in an insulated ceiling.

Question 18: Which of the following recessed luminaires can be located within 2 inches of thermal insulation?

A: Any luminaire.
B: A luminaire without any markings.
C: A luminaire marked Type IC.
D: A Non-Type IC luminaire.

Question 19: 590.3(D) Removal of Temporary Wiring.

Question ID#: 10353.0



Temporary wiring above a ceiling must be removed immediately upon completion of construction or purpose for which the wiring was installed.

Temporary wiring that has been installed during the construction phase must be removed before calling for a final inspection.

For temporary use, such as construction power, Article 590 allows substandard wiring practices including open splices without a box, Nonmetallic-sheathed cables (NM) installed open, without concealment and NM cables in wet locations or other locations not normally allowed by the Code. Although these practices are temporarily allowed during construction, they cannot be present in the completed project. Section 590.3(D)requires temporary wiring to be removed ***immediately upon completion of construction or purpose for which the wiring was installed.***

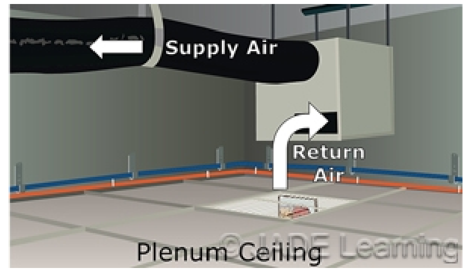
Generally, the inspector will not approve the installation of any ceiling tiles until all temporary lighting and associated wiring methods have been removed.

Question 19: Which of the following is true of temporary wiring on a job site?

A: Splices must always be in a box.
B: It must be removed immediately upon completion of construction.
C: It must be removed within 90 days after the project is complete.
D: It can remain as long as it cannot be energized.

Question 20:   300.22(C) Other Spaces Used for Environmental Air.

Question ID#: 10354.0



Plenum ceilings exist when return air is pulled through and circulates within the above ceiling space. In this case, metallic wiring methods or plenum-rated wiring methods are required.

Sometimes the space above a suspended ceiling is considered a plenum. A plenum exists when return air is pulled through the above-ceiling space, before it enters the HVAC unit installed above the ceiling grid, where it is conditioned and supplied back throughout the building.

If flexible or solid ductwork is installed from the ceiling register to the return side of the above-ceiling HVAC unit, the air system is sealed and no air circulates in the above-ceiling space. When only a dummy grill is installed in the ceiling and return air is pulled through it into the above-ceiling space before reaching the return air side of the unit, a plenum exists. Wiring methods in plenums are required to be metal or limited to those with low smoke and heat release properties in order to avoid toxic fumes or smoke from a burning cable entering into the supply air system. Even cable ties must be listed as low smoke producing.

Section 300.22(C) only allows the following 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.
- Factory-assembled multiconductor control or power cable that is specifically listed for use within an air handling space.
- Listed prefabricated cable assemblies of metallic manufactured wiring systems without a nonmetallic sheath.

Other types of cables or conductors if 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.

Question 20:   Which of the following wiring methods can be installed in a plenum ceiling?

A: Nonmetallic sheathed cable.
B: PVC electrical raceways.
C: Type AC Cable.
D: PVC coated MC Cable.

Question 21: 250.104(A)(B)(C) Bonding of Piping and Exposed Structural Steel.

Question ID#: 10355.0

Bonding of piping and exposed structural steel includes bonding to water pipe, gas pipe, and steel. However, there are many types of metal piping systems installed in buildings. Copper vacuum and compressed air lines are often installed in machine shops and wood working shops. In hospitals, dental offices, and other health care facilities, there can be medical gas, oxygen, compressed air, and vacuum systems. Most often, the metal piping systems and exposed structural steel are bonded above the suspended ceiling since that area is one of the only locations where those items are physically exposed. Concealed structural steel is not likely to become energized and is not required to be bonded unless it is being used as the actual grounding electrode in accordance with 250.52(A)(2).

Bonding is required of all metal piping systems installed in a building.

Section 250.104 requires the following to be bonded:

- ***Metal water piping.*** The points of attachment of the bonding jumper must be accessible.
- ***Other metal piping.*** This includes the items mentioned above and is required if the piping system ***is likely to become energized***. The best idea is to consider it ***likely to become energized*** because the inspector will.
- ***Structural metal.*** This section is all about "exposed structural metal". Not all metal in a building is "structural" or "exposed". The bonding point must be accessible unless joined by exothermic welding, irreversible compression connection, or regular attachment but covered with fireproofing materials such as Monokote.
- ***Separately derived systems.*** Those systems will be covered elsewhere in the course when transformers are discussed.

Metal piping systems can be bonded to any of the following:

- 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.

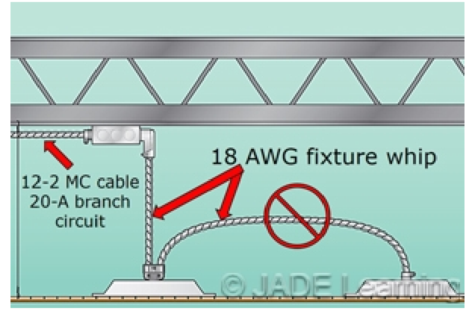
Question 21: Which of the following must be bonded?

A: Exposed non-structural steel.
B: Concealed structural steel.
C: A structural steel I-beam, exposed above a suspended ceiling.
D: Exposed PVC water piping systems.

Question 22: 410.117(C) Luminaires. Tap Conductors.

Question ID#: 10356.0

Most often, lay-in type luminaires installed in a grid ceiling are connected via the factory made fixture whip that comes with the luminaire. The No. 18 AWG fixture whip is installed to a junction box above the ceiling and connected to a 20 ampere branch circuit, supplied by No. 12 AWG copper wire. Most fixture whips are made of No. 18 AWG copper insulated conductors installed in a length of metal cable armor with connectors at each end. Section 240.5(B)(2) allows up to a 20 ampere overcurrent device to supply the No. 18 AWG fixture whip even though the fixture wire is only rated for 6 amps according to NEC Table 402.5. Technically, the No. 18 AWG fixture wire is considered a "tap conductor".



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.

A common violation is to daisy chain several fixtures together by No. 18 AWG fixture whips and then one final No. 18 AWG fixture whip is run from the last luminaire to the box containing the 20 ampere branch circuit conductors. This is a violation of the following tap conductor rules in the NEC:

- Section 240.2 defines a tap conductor as ***a conductor, other than a service conductor, that has overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors that are protected as described elsewhere in 240.4***.
- Section 240.21 states that branch circuit tap conductors shall not supply another conductor except through an overcurrent protective device.
- Section 410.117(C) only permits tap conductors to be run from the fixture to the outlet box, but the tap conductors cannot be more than 6 ft. in length.

In a nutshell, if the plan is to daisy chain from light to light on a 20 ampere circuit, plan on using No. 12 AWG copper MC Cable between fixtures and to the final junction box instead of the factory made No. 18 AWG fixture whips.

Question 22: Which of the following is true of a branch circuit fixture tap conductor?

A: Taps are permitted to extend to several luminaires.
B: They cannot supply another conductor except through an overcurrent device.
C: They are not permitted to be used at all for luminaires.
D: They must never be smaller than No. 16 AWG.

Question 23: 300.21 Spread of Fire or Products of Combustion.

Question ID#: 10357.0

Section 300.21: ***Openings around electrical penetrations into or through fire resistant-rated walls, partitions, floors, or ceilings shall be fire-stopped using approved methods to maintain the fire resistance rating***.

Being aware of any rated fire walls or fire barriers on a construction project is key. Penetrations through rated walls, ceilings, floor/ceiling assemblies, and the like are all covered in the Building Code, but the NEC also mentions them 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 readily identifiable as a rated wall. Check the plans for locations of any rated walls or rated floor/ceiling assemblies that might be present before penetrating it.

It is important to know where rated walls might exist on a new build or a remodel. When punching holes in the demising wall (separation wall between occupancies), above the ceiling in order to run a new feeder, or fishing MC cables down the demising wall for branch circuits, proper fire stopping of any new wiring methods is required by the NEC and will be enforced by the inspector.

Holes cut in fire-rated walls need to be precise. The manufacturer of each type of fire sealant or fire caulking will specify the minimum and maximum annular space requirements around a penetration being sealed. Annular space is the distance between the interior surface of the opening and the exterior surface of the penetrating item. In order to use the fire caulking or other approved product within its listing, the annular space around a penetration must be within a certain measurement as required in the instructions for each specific product. (See ASTM E 814 or UL 1479).

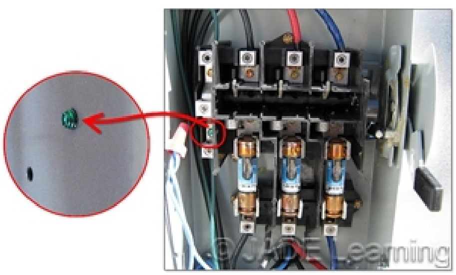
Question 23: Which of the following is required for materials used to seal an electrical penetration through a firewall?

A: They must be red in color.
B: They must have a smoke-developed index of 500 or less.
C: They must have a flame spread index of 50 or less.
D: Only approved firestopping methods can be used.

Rooftop

Question 24: 250.110 Equipment Fastened in Place or Connected by Permanent Wiring Methods.

Question ID#: 10359.0



Front and back view. With the bonding screw installed, the EGC now has direct contact with the metal enclosed rooftop equipment.

Section 250.110: Exposed, normally non-current-carrying metal parts of fixed equipment supplied by or enclosing conductors or components that are likely to become energized shall be connected to an equipment grounding conductorunder any of the following conditions:

(1) Where within 8 ft. vertically or 5 ft. horizontally of ground or grounded metal objects and subject to contact by persons

(2) Where located in a wet or damp location and not isolated

(3) Where in electrical contact with metal

(4) Where in a hazardous (classified) location as covered by Articles 500 through 517

(5) Where supplied by a wiring method that provides an equipment grounding conductor, except as permitted by 250.86 Exception No. 2 for short sections of metal enclosures

(6) Where equipment operates with any terminal at over 150 volts to ground.

Rooftop air conditioners, exhaust fans, evaporative coolers, and refrigeration equipment are all examples of fixed-in-place equipment, installed outdoors in wet locations, that often operate greater than 150 volts to ground.

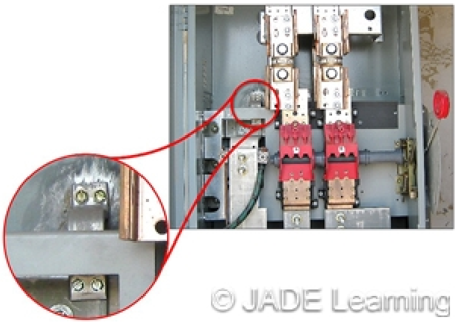
If any portion of the wiring method supplying fixed equipment is nonmetallic, or does not qualify as an equipment grounding conductor (EGC) in accordance with 250.118, an equipment grounding conductor (EGC) supplied with the wiring method must be used to ground the equipment. This is generally done inside the disconnect switch enclosure for the equipment. Most switches used on rooftop equipment will come with an optional bonding screw for this purpose, and it's one of the first things the electrical inspector will look for. The equipment grounding conductor (EGC) is connected to a floating terminal that has no continuity with the metal enclosure unless the bonding screw is used. The screw is long enough to go clear through and penetrate the back of the metal switch enclosure. With the bonding screw installed, the equipment grounding conductor (EGC) now has direct contact with the metal enclosed rooftop equipment.

Question 24: What is required of fixed-in-place electrical equipment?

A: The metal enclosure must be connected to a grounded neutral conductor.
B: The metal enclosure must be connected to an ungrounded conductor.
C: The metal enclosure must be connected to a grounding electrode conductor.
D: The metal enclosure must be connected to an equipment grounding conductor.

Question 25: 250.12 Clean Surfaces.

Question ID#: 10360.0



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

Proper grounding of equipment means a good metal to metal connection so that any possible fault on a grounded surface is easily recognized as a fault by the overcurrent device supplying the equipment. The ground-fault current path back to the source should not be hindered by nonconductive materials, coatings, or loose connections. Poor or loose grounding connections at equipment could diminish the amount of ground-fault current returning back to the power source which could cause the overcurrent device to regard a fault condition as a load rather than an actual fault condition. When the overcurrent device is aware that a ground-fault current exists, it will trip.

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

Some electrical equipment comes with factory punched holes and hardened steel bonding screws that have been pre-designed to remove paint and mate perfectly when driven into the enclosure. The combination of the flared edge of a punched hole in a mild steel enclosure and a properly matched hardened steel machine screw puts the perfect amount of screw threads in contact with the enclosure without requiring paint removal. The paint is automatically removed by simply driving the screw into the enclosure as intended by the manufacturer.

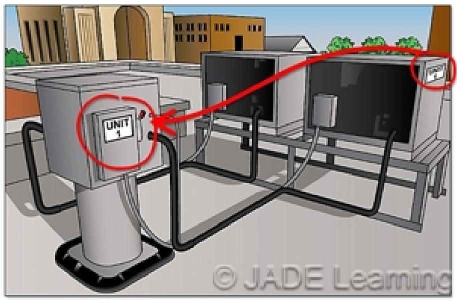
Field drilled holes in metal enclosures require paint removal before the grounding terminal is attached. A good way to ensure a passing inspection every time is to always scrape the paint whether it needs it or not.

Question 25: Which of the following must be removed to ensure proper electrical continuity?

A: Conductive coatings under a grounding lug.
B: Enamel under a grounding lug.
C: The equipment grounding conductor.
D: Bonding screws.

Question 26: 110.22(A) Identification of Disconnecting Means.

Question ID#: 10361.0



A disconnecting means must be identified if its purpose is not evident.

Section 110.22(A): Each disconnecting means shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident. The marking shall be of sufficient durability to withstand the environment involved.

The majority of disconnecting switches are installed on or adjacent to the equipment they supply. The NEC provides ***minimum*** requirements to protect people from electrical hazards. Nothing in the Code prohibits doing more than the minimum. It's always a good idea to label a disconnect switch as to what it controls even if the purpose is evident. What may be evident to one person is not always evident to someone else.

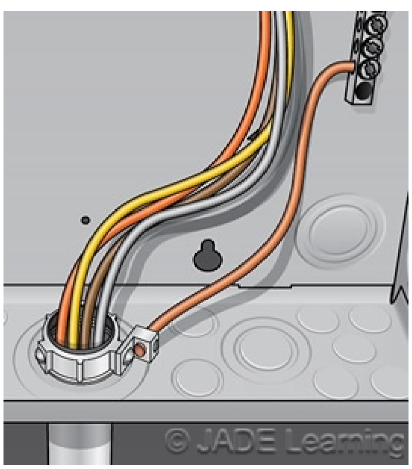
Disconnect switches are often examined or worked on while energized. Voltage testing is usually required when troubleshooting. It is important to provide adequate work space at a disconnect switch, and it is a good practice to include the panel number and circuit numbers that supply the disconnect switch. That way the circuit feeding the disconnect can be easily located and de-energized while the equipment is being repaired.

Question 26: Which disconnecting means must be identified as to its purpose?

A: A switch that is mounted on the equipment it supplies.
B: A disconnect switch that is grouped with many other similar disconnect switches.
C: A factory installed molded case switch on a rooftop air conditioner.
D: A light switch in an electrical room.

Question 27: 250.97 Bonding for Over 250 volts.

Question ID#: 10362.0



If not punching out all of the knockout rings and using a connector that fills the entire hole, plan on using bond bushings when installing conductors over 250 volts to ground.

For circuits of more than 250 volts to ground (277/480 volt systems, for example) the electrical continuity of metal raceways and cables with metal sheaths containing conductors other than service conductors, must be ensured by at least one of the following methods:

- Connections utilizing threaded couplings or threaded hubs on enclosures if made up wrenchtight.
- Threadless couplings and connectors if made up tight for metal raceways and metal-clad cables.
- Other listed devices, such as bonding-type locknuts, bushings, or bushings with bonding jumpers.

These additional bonding methods are required even if a wire-type equipment grounding conductor is installed in the raceway, but there are some exceptions.

Exception:Where oversized, concentric, or eccentric knockouts are NOT encountered, or where a box or enclosure with concentric or eccentric knockouts is listed to provide a reliable bonding connection, the following methods shall be permitted.

Simply put, if field drilling holes or punching out all the rings of a knockout, or if the enclosure is listed for bonding around concentric/eccentric knockouts without punching all knockout rings, the following bonding methods can be used:

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

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

inside and one outside of boxes and cabinets.

(3) Fittings with shoulders that seat firmly against the box or cabinet, such as electrical metallic tubing connectors, flexible metal conduit connectors, and cable connectors, with one locknut on the inside of boxes and cabinets.

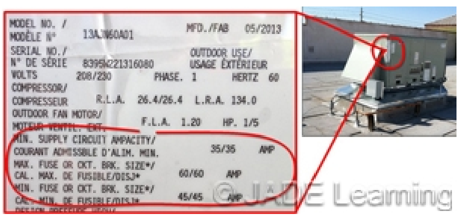
(4) Listed fittings.

Question 27: Which of the following can be used to ensure electrical continuity of a raceway to an enclosure with 277 volt circuits?

A: Insulated plastic bushings.
B: Listed bonding bushings.
C: Threaded rigid metal conduit with only one locknut on the inside of the enclosure.
D: Steel locknuts on a raceway made up hand tight.

Question 28: 440.4(B) Marking on HVAC Equipment.

Question ID#: 10363.0



When the minimum circuit ampacity and maximum size OCPD are marked on the nameplate, no additional math or calculation is required. In rare cases, such as this one, even the minimum OCPD is mentioned on the nameplate.

Most HVAC units have more than just a single motor. If an HVAC unit incorporates a hermetically sealed refrigerant motor-compressor and other loads, such as a cooling fan, then the unit will be considered "Multimotor and Combination-Load Equipment" which is covered in 440.4(B).

Section 440.4(B) requires all multimotor and combination-load equipment to have a nameplate marked with the minimum supply circuit ampacity and maximum overcurrent device. These marking requirements are beyond the control of the electrician or inspector and are clearly meant for the equipment manufacturer to comply with. Part of this marking requirement is that the values determined for the minimum circuit conductor size and maximum overcurrent device are derived from the calculations mentioned in Parts III and IV of Article 440. The equipment manufacturer will use these parts of Article 440 for determining the final values stamped on the nameplate.

When these values are provided by the manufacturer, no further calculation is needed. For the nameplate in the image of the rooftop unit, select a branch circuit conductor that can carry 35 amps and use no more than a 60 amp fuse or circuit breaker for the overcurrent protection.

Question 28: According to the image of the rooftop unit nameplate, what is the minimum size overcurrent device that can be used for this equipment?

A: 35 amps.
B: 45 amps.
C: 55 amps.
D: 60 amps.

Question 29: 314.23(E)&(F) Raceway Supported Enclosures.

Question ID#: 10364.0

Boxes can be supported solely by the raceways that supply it if there are two or more raceways threaded wrench-tight into the enclosure and the raceways are secured within a certain distance of the enclosure.

In general, a box cannot be supported solely by the raceways that enter the box, with no other means of securing or supporting. However, an enclosure can be supported solely by raceways if the following conditions are met:

- The enclosure must be supported by two or more conduits threaded wrench-tight into the enclosure or hubs that are part of the enclosure.
- The enclosure cannot be greater than 100 cubic inches.
- If the enclosure contains only splices, each conduit shall be secured within 3 ft. of the enclosure, or within 18 in. of the enclosure if all conduit entries are on the same side.
- If the enclosure contains splices, devices, luminaires, or lampholders, each conduit shall be secured within 18 in. of the enclosure.
- There is an exception for supporting conduit bodies with a single raceway, if the raceway is Type IMC, RMC, PVC, RTRC or EMT. Another exception permits an unbroken length of RMC or IMC to support a box used for luminaire or lampholder support.

The first bullet point above makes an important point.***The enclosure must be supported by two or more conduits threaded wrench-tight into the enclosure.***

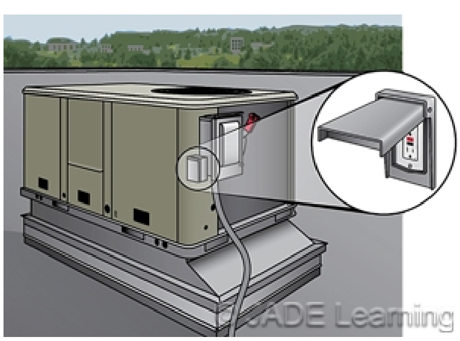
In order to "thread" a conduit into an enclosure, the conduit must have threads. Only rigid metal conduit (RMC) and intermediate metal conduit (IMC) have threads. Threading a compression connector into the box for attachment of a raceway or screwing a PVC male adapter into the box and then gluing a PVC raceway to it does not comply with the NEC. The only way to truly comply with this Code section is to use two or more RMC or IMC raceways with threads.

Question 29: Which of the following can be used as the sole support of a single gang weatherproof junction box?

A: Two schedule 80 PVC conduits.
B: Two PVC raceways connected to the box by male adapters that have been threaded wrenchtight into the box.
C: Two sections of electrical metallic tubing connected to the box with connectors.
D: Two rigid metal conduits threaded wrenchtight into the box.

Question 30: 210.63 Heating, Air-Conditioning, and Refrigeration Equipment Outlet.

Question ID#: 10365.0



Some HVAC units have factory installed service receptacles while others do not. One receptacle strategically placed on a rooftop can serve multiple HVAC units that all have the same requirement for a service receptacle within 25 ft.

Service receptacles near HVAC equipment are often used by HVAC technicians when troubleshooting problems or charging air conditioning or refrigeration equipment with coolant. The NEC requires a 125-volt, single-phase, 15- or 20-ampere receptacle outlet to be located within 25 ft. of the HVAC equipment specifically for this purpose. The receptacle outlet must meet the following conditions:

- It must be in an accessible location.
- It must be on the same level as the HVAC equipment.
- It must be within 25 ft. of the HVAC equipment.
- It cannot be connected to the load side of the equipment disconnecting means.

Exception: A receptacle outlet is not required at one- and two-family dwellings for the service of an evaporative cooler.

The last bullet point listed above requires that the service receptacle ***cannot be connected to the load side of the equipment disconnecting means***. If the receptacle is connected to the load side of the HVAC unit disconnect switch, then the receptacle will have no power when the disconnect switch is turned off. In this case, the HVAC technician will just work on the HVAC unit while energized in order to avoid shutting off the service receptacle and losing power to his tools and equipment. Connecting the service receptacle to the line side of the disconnect switch or simply providing a separate circuit for the service receptacle is much safer.

Question 30: Which of the following receptacles can be used to serve a rooftop air conditioner?

A: One that is fed from the load terminals of the HVAC unit disconnect switch.
B: A single-phase, 30-ampere receptacle fed from the line side of the HVAC unit disconnect switch.
C: One that is rated for three phase applications.
D: A 15-ampere, single-phase, 125-volt receptacle that is supplied from a separate circuit and not switched by the HVAC unit disconnect switch.

Service, Panelboards, Transformers

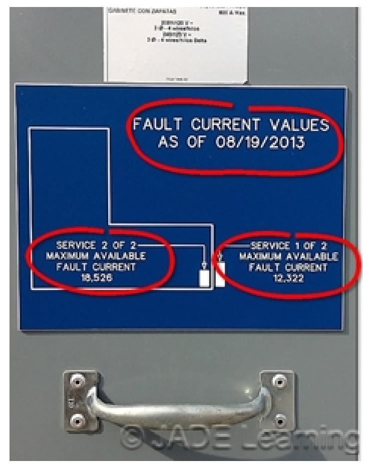
Question 31: 110.24 Available Fault Current.

Question ID#: 10367.0

Service equipment for other than dwellings must be marked with the available fault current. This is for proper selection of equipment at the service and downstream of the service.

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. This means the device normally interrupts current over 20 amps but in the event of a larger fault condition, the breaker can interrupt 10,000 amps without blowing up.

Passive components such as lighting contactors are assigned a short-circuit current rating (SCCR). This is the amount of current they can be connected to without blowing up. A 30 ampere contactor, for example, might also have a SCCR of 5,000 amps. This means it can continually switch up to a 30 amp load but can also be subjected to 5,000 amps of fault current without blowing up.



Service equipment in other than dwellings must be marked with the maximum available fault current and the date the fault current calculation was performed. These values are normally obtained from the utility provider.

The AIC rating of circuit breakers and the SCCR of passive components are chosen based on the amount of available fault current as required by Sections 110.9 and 110.10.

Section 110.24 requires the following:

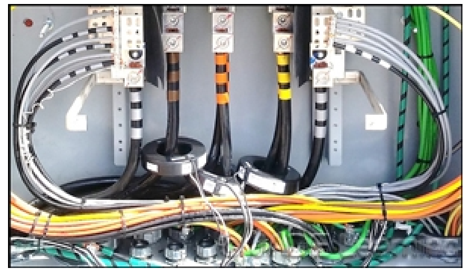
- Service equipment in other than dwellings be legibly field marked with the maximum available fault current.
- The field marking must include the date the fault-current calculation was performed and be sufficient to withstand the environment involved.
- For modifications that affect the maximum available fault current, the maximum available fault current must be verified or recalculated to ensure the service equipment ratings are sufficient for the maximum available fault current. The required field marking in 110.24(A) must be adjusted to reflect the new level of maximum available fault current.

Question 31: Which of the following must be marked with the maximum available fault current?

A: Subpanels supplied by a feeder.
B: Service equipment at a commercial building.
C: Service equipment at a single family dwelling.
D: An enclosure containing a lighting contactor.

Question 32: 200.6 Identification of Grounded Conductors.

Question ID#: 10368.0



White, gray, or three continuous white or gray stripes on other than green insulation are proper identification methods for a grounded conductor.

Grounded neutral conductors should never be confused with equipment grounding conductors or ungrounded conductors.

A grounded neutral conductor normally carries current as its main principle function. An equipment grounding conductor only carries current for a short time during a ground-fault condition. Because the purpose of a grounded neutral conductor differs so greatly from equipment grounding conductors and ungrounded conductors, it requires special identification.

Section 200.6 provides rules on identifying grounded neutral conductors. Below are the most commonly used methods.

Sizes No. 6 AWG or smaller:

- A continuous white outer finish.
- A 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 methods as above or, at the time of installation, by a distinctive white or gray marking at its terminations that encircles the conductor insulation.

One of the most common violations an inspector looks for is the misapplication of the identification rules listed above. Here are a few simple tips to always apply the rules correctly:

- Size No. 6 AWG or smaller includes size No. 6 AWG and everything smaller. Size No. 6 AWG or smaller does NOT mean only sizes smaller than No. 6 AWG.
- Size No. 4 AWG or larger includes size No. 4 AWG and everything larger. Size No. 4 AWG or larger does NOT mean only sizes larger than No. 4 AWG.

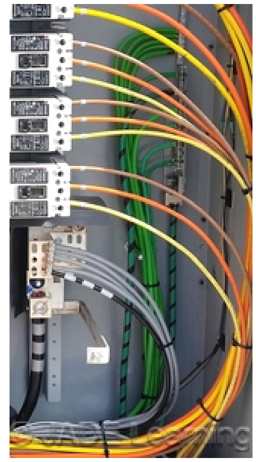
Question 32: Which of the following grounded conductors can be a black wire, identified with white marking tape at the termination?

A: Size No. 4 AWG.
B: Size No. 6 AWG.
C: Size No. 8 AWG.
D: Size No. 10 AWG.

Question 33: 250.119 Identification of Equipment Grounding Conductors.

Question ID#: 10369.0

Equipment grounding conductors should never be confused with grounded or ungrounded conductors.Equipment grounding conductors provide a ground-fault current path from circuits and equipment back to a grounding busbar at the service, where the main bonding jumper joins them to the grounded conductor. From there, the ground-fault current can return back to the source on the grounded service conductor. This process causes the overcurrent device ahead of the faulted circuit to trip.



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

An equipment grounding conductor does not normally carry current which is why it can be sized significantly smaller than grounded neutral conductors and ungrounded conductors. An equipment grounding conductor only carries current for a short time during a ground-fault condition. Because the purpose of an equipment grounding conductor differs so greatly from grounded conductors and ungrounded conductors, it requires special identification.

- Section 250.119 provides rules on identifying equipment grounding conductors. Below are the most commonly used methods.

Sizes No. 6 AWG or smaller:

- Bare conductor.
- Continuous green outer finish.
- Continuous green outer finish with one or more yellow stripes.

Sizes No. 4 AWG and larger:

- Same as above or, at the time of installation, permanently identified as an equipment grounding conductor at each end and at all accessible points. (Can be stripped bare where exposed, green tape, green coloring at the termination).
- Check all exceptions.

Here are a few simple tips to apply the rules for correctly identifying the equipment grounding conductor:

- Size No. 6 AWG or smaller includes size No. 6 AWG and everything smaller. Size No. 6 AWG or smaller does NOT mean only sizes smaller than No. 6 AWG.
- Size No. 4 AWG and larger includes size No. 4 AWG and everything larger. Size No. 4 AWG and larger does NOT mean only sizes larger than No. 4 AWG.

Question 33: Which of the following equipment grounding conductors can be a black wire, identified only by green marking tape at the termination?

A: Size No. 4 AWG.
B: Size No. 6 AWG.
C: Size No. 8 AWG.
D: Size No. 10 AWG.

Question 34: 210.5(C) Identification of Ungrounded Conductors.

Question ID#: 10370.0

There are no specific color codes required for ungrounded conductors. The industry standard used by most electricians is black, red, blue, brown, orange, and yellow, but these are not required by the NEC. The NEC provides rules on ungrounded conductor identification in negative language by stating what not to use. By process of elimination, ungrounded conductors can be anything except bare, green, white, or gray.

__When a premises has circuits supplied from more than one nominal voltage system, the color scheme of ungrounded conductors must be identified at all termination, connection, and splice points.__

When another alternating current system is present (a transformer or second service) with different voltage characteristics, a hazard exists for those troubleshooting, maintaining, or installing new wiring unless circuit identification is clearly evident. Opening a junction box above a grid ceiling only to find that all ungrounded conductors are black and all grounded conductors are white, regardless of voltage, creates a nightmare for the service electrician. Because of this, the NEC requires ungrounded conductors to be distinguishable from one voltage system to another.

__NEC 210.5(C):__ ***__Where the premises wiring system has branch circuits supplied from more than one nominal voltage system, each ungrounded conductor of a branch circuit shall be identified by phase or line and system at all termination, connection, and splice points__***.

- The means of identification can be color coding, marking tape, tagging, or other approved means.
- The method used for conductors originating from panelboards or similar distribution equipment shall be documented and readily available or shall be permanently posted at each branch-circuit panelboard or similar distribution equipment.

Similar rules are found in 215.12(C) for feeders. Although this is a step in the right direction, there are still no similar rules that require grounded neutral conductors to be distinguishable from one voltage system to another. White or gray can be used for the grounded neutral conductors in a 120/208-volt system and then again for the 277/480-volt system in the same building, although it is not a good practice.

Question 34: When must the color scheme of ungrounded conductors be identified at a panelboard?

A: When 120 volt systems exist on a premises.
B: Always, regardless of how many systems the premises may be supplied from.
C: When a premises has circuits supplied from more than one nominal voltage system.
D: When 208 volt systems exist on a premises.

Question 35: 110.26(A)(1) Working Space.

Question ID#: 10371.0

Working space is required any time there is a possibility that equipment could be examined or worked on while energized. Even equipment that will not be worked on while energized still requires proper access. Section 110.26 states that ***access and working space shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment***.

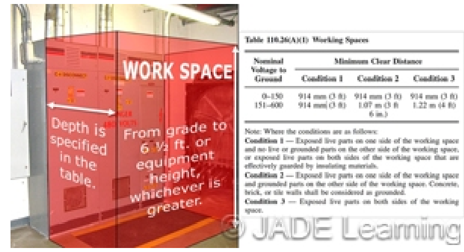


Table 110.26(A)(1) Working Spaces

Nominal Voltage to Ground	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
0–150	914 mm (3 ft)	914 mm (3 ft)	914 mm (3 ft)
151–600	914 mm (3 ft)	1.07 m (3 ft 6 in.)	1.22 m (4 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.

Table 110.26(A)(1).

Section 110.26(A)(1) addresses equipment rated 600 volts or less to ground that is likely to be examined, adjusted, serviced, or maintained while energized. Working space for such equipment must comply with the dimensions shown in Table 110.26(A)(1) as can be seen in the image. Below is a general summary of the requirements in 110.26(A)(1)(2)&(3):

- The dimensions specified in the table show the depth of the required working space which is based on site-specific conditions listed under the table and the equipment voltage to ground. Distances shown in the table are measured from any exposed live parts or from the enclosure if the live parts are enclosed.
- The width of the working space in front of equipment is 30 in. or the width of the equipment, whichever is greater, and in all cases the work space must allow for all hinged equipment doors to be openable to at least 90 degrees.
- The height of the required working space is from grade to a height of 6 1/2 ft. or the height of the equipment, whichever is greater.

Additional requirements listed in 110.26(A)(1)(a)(b)&(c)cover rear access clearances, low voltage installations, and working space allowances for existing buildings.

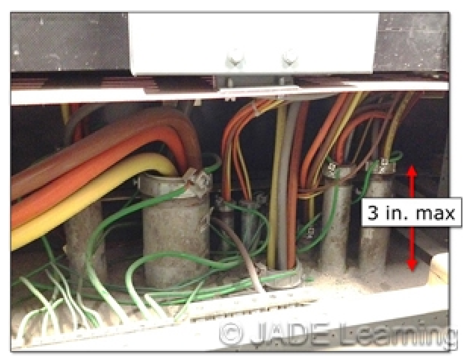
Question 35:   What is the depth of working space required for a 208Y/120 volt, 3-phase panelboard located opposite a brick (grounded) wall?

A: 2 ft.
B: 3 ft.
C: 3 ft. 6 in.
D: 4 ft.

Question 36: 408.5 Clearance for Conductor Entering Bus Enclosures.

Question ID#: 10372.0

When installing under-slab conduits before concrete is poured, knowing the size and physical dimensions of a floor standing or open bottom switchboard makes for an almost foolproof switchboard installation later. Before the slab is poured, it is crucial to double and triple check measurements to ensure that the entering raceways will actually land in the correct section of the future switchboard enclosure. As well, the height of the raceways as they extend above slab is important, especially if installing threaded rigid conduit.



Raceways entering an open bottom switchboard enclosure cannot extend more than 3 in. into the enclosure.

Metal conduits entering an open bottom enclosure are required to be bonded to the equipment grounding bar in order to maintain electrical continuity, and the only way that can happen is by threaded fittings or compression connectors installed on the entering raceways. In the event that the entering raceways are too tall or rise up into the enclosure too much, the following problems occur:

- It can be difficult to make the final wire pulls without damaging conductors if raceways are too close to busbars or other obstructions in the enclosure.
- If conduits must be cut shorter, it will most likely be done by hand with a hack saw because of limited space after a switchboard is set.
- Threaded rigid conduits that have been cut shorter must now have the edges cleaned up to protect conductors from abrasion.

- Threaded rigid conduits that have been cut short can only be connected to by expensive compression fittings so that additional threaded bond bushings can then be installed to bond the metal raceways to the enclosure.

For several reasons, Section 408.5 states that conduits or raceways, including their end fittings, shall not rise more than 3 in. above the bottom of the enclosure.

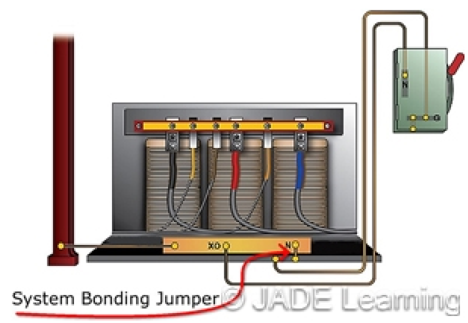
Question 36: Which of the following raceways entering the bottom of an open bottom switchboard enclosure is Code compliant?

A: A 2 in. rigid metal conduit rising up 4 inches above the bottom of the enclosure.
B: A 2 in. rigid metal conduit rising up 5 inches above the bottom of the enclosure.
C: A 2 in. rigid metal conduit rising up 6 inches above the bottom of the enclosure.
D: A 2 in. rigid metal conduit rising up 2 inches above the bottom of the enclosure.

Question 37: 250.30(A)(1) System Bonding Jumpers.

Question ID#: 10373.0

Section 250.30(A)(1) is all about the system bonding jumper in separately derived alternating current systems. Many transformers are separately derived systems (SDS). 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***.



The system bonding jumper can be installed in the transformer enclosure or at the first disconnecting means, but not at both locations, unless an exception is permitted.

Grounding a separately derived system is similar to grounding a service. There must be a place where the system grounded conductor has a direct connection to the equipment grounding conductors and metal enclosure. In a service, this is done by a main bonding jumper that joins the grounded conductor to the equipment grounding conductors. In a SDS, a system bonding jumper (SBJ) serves this purpose. The system bonding jumper (SBJ) is usually the first thing the inspector will look for after the transformer cover is removed. The inspector will want to make sure the system bonding jumper (SBJ) is present and sized properly. There are no identification requirements for a system bonding jumper (SBJ) in the NEC and nothing requiring the system bonding jumper (SBJ) to be insulated (See NEC 250.28).

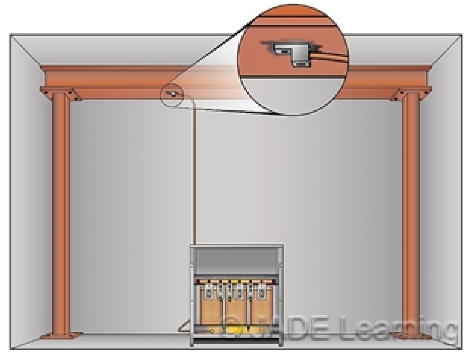
Generally, the system bonding jumper is permitted to be connected at the transformer or at the first disconnecting means after the transformer, but not both, unless allowed by an exception. System bonding jumpers are sized from NEC Table 250.102(C)(1), based on the size of the ungrounded secondary conductors.

Question 37: Where can the system bonding jumper be connected?

A: Both inside the transformer and inside the first disconnecting means, simultaneously.
B: In the disconnecting means before the transformer.
C: Inside the transformer, or at the first disconnecting means after the transformer. But not both simultaneously.
D: In the panelboard that supplies the primary side of the transformer.

Question 38:   250.30(A)(4&5) Grounding Electrode and Grounding Electrode Conductor, Single Separately Derived System.

Question ID#: 10374.0



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

Sections 250.30(A)(4)&(5) provide the rules on how to ground a separately derived system (SDS) to earth. Most transformers are separately derived systems and must have a grounding electrode conductor (GEC) connected to a grounding electrode. At the other end, the grounding electrode conductor must connect to the grounded conductor of the separately derived system at the same location as the system bonding jumper (SBJ) for the system. If the system bonding jumper is located in the transformer, then 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.

Section 250.30(A)(4) requires the grounding electrode for a separately derived system to be as near as practicable to, and preferably in the same area as, the grounding electrode conductor connection to the "system" (in this case, the "system" is the transformer). The grounding electrode should be a metal water pipe or structural metal in the same area as the transformer, but only if those items actually qualify as a true grounding electrode in accordance with 250.52(A)(1)&(2). If neither of those electrodes are available, any of the other grounding electrodes listed in 250.52(A) can be used.

Even if the nearby structural metal and metal water pipe do not actually qualify as a true grounding electrode, they are both still required to be bonded back to the transformer according to 250.104(D). Doing so places these items on the same potential to ground. In many cases, the nearby structural steel or water piping requiring bonding per 250.104(D) will also qualify as the grounding electrode for the transformer per 250.52(A)(1&2).

Grounding electrode conductors are sized from NEC Table 250.66, based on the size of the transformer's ungrounded secondary conductors, but they are never required to be larger than 3/0 AWG copper or 250 kcmil aluminum.

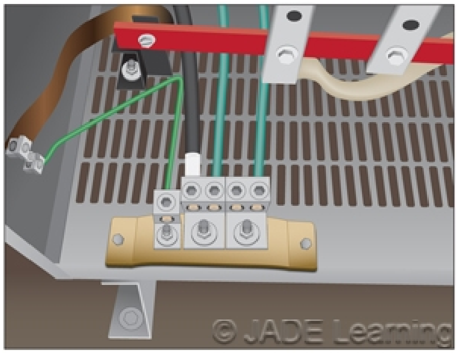
Question 38:   Where is the grounding electrode conductor to be terminated for a separately derived system?

A: Both inside the transformer and inside the first disconnecting means.
B: At the main electrical service.
C: At the disconnecting means that supplies the primary side of the transformer.
D: To the grounded conductor, at the same location where the system bonding jumper is located.

<u>Final Inspection</u>

Question 39: 450.10(A) Grounding of Dry-Type Transformer Enclosures.

Question ID#: 10376.0



Where separate equipment grounding conductors and supply-side bonding jumpers are installed, a terminal bar is required for the connections, and it cannot be installed over the ventilation openings.

Grounding methods for equipment grounding conductors and supply-side bonding jumper connections within a transformer can be confusing.

Section 450.10(A) is all about the dry-type transformer enclosure and requires the following:***Where separate equipment grounding conductors and supply-side bonding jumpers are installed, a terminal bar for all grounding and bonding conductor connections shall be secured inside the transformer enclosure. The terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any vented portion of the enclosure***.

The Code section says: ***A terminal bar for all grounding and bonding conductor connections shall be secured inside the transformer enclosure.*** "A terminal bar" means ONE terminal bar, not several individual separate grounding lugs.

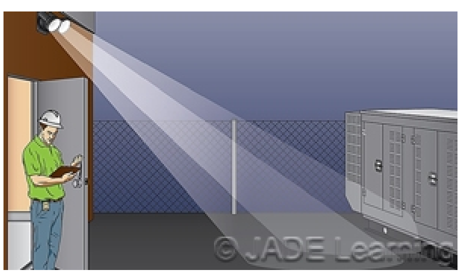
Notice the last sentence from the same Code section above:***The terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any vented portion of the enclosure***. "The terminal bar" means ONE terminal bar, and it cannot be installed over the transformer vents. Bonding terminals installed over perforated metal creates an impaired metal-to-metal connection, and it 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.

Question 39: Which of the following bonding methods is permitted for a dry-type transformer?

A: An equipment grounding conductor and main bonding jumper, both terminated on separate terminal bars in the transformer.
B: An equipment grounding conductor and supply-side bonding jumper, both terminated at the same terminal bar in the transformer.
C: A grounded conductor and an ungrounded conductor terminated on the same terminal bar in the transformer.
D: An equipment grounding conductor and an ungrounded conductor terminated on the same terminal bar in the transformer.

Question 40: 700.12 General Requirements.

Question ID#: 10377.0



In the event of normal power supply failure, emergency lighting, emergency power, or both, shall be available within the time required for the application but not to exceed 10 seconds.

In the event of normal power supply failure, emergency lighting, emergency power, or both, must be available within the time required for the application but not to exceed 10 seconds.

Whether an emergency generator supplies lighting systems in the building through an automatic transfer switch, or if emergency lighting is supplied from battery backup within each luminaire- either way, when power goes out, the emergency lighting must initiate within 10 seconds. Depending on the size of the jurisdiction, the electrical inspector, building inspector, or the fire marshal may be responsible for final testing and acceptance of the emergency system in a building.

If a generator provides backup power for the emergency lighting and power systems, the most common way to test it is for the inspector to stand at an exit with the door open, at a place in the building closest to the outdoor generator. From there, the inspector can start the timer as soon as the electrician switches off the service disconnect to see how long it takes for the generator to start. Standing in the building as close as possible to the generator allows the inspector to hear the generator start up and see the emergency lights in the exit corridor illuminate within 10 seconds upon loss of power.

If the backup power comes from internal emergency batteries in the unit equipment (emergency lights and exit signs), then the inspector will generally ask that all lighting circuits in the building be switched off at the circuit breaker. Once all lighting circuits are off, the inspector walks through the building, counting the number of illuminated emergency lights and exit signs running on battery power, to see if the number installed and location installed matches the approved plans.

Question 40: Which of the following emergency systems is installed correctly?

A: An emergency generator that has emergency lights up and running 30 seconds after normal power is lost.
B: An emergency generator that has emergency lights up and running 15 seconds after normal power is lost.
C: An emergency generator that has emergency lights up and running 12 seconds after normal power is lost.
D: An emergency generator that has emergency lights up and running 8 seconds after normal power is lost.

Question 41: 700.16 Emergency Illumination.

Question ID#: 10378.0

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.

One of the most common correction items at a final inspection is emergency lighting and exit signs (unit equipment) not functioning as intended. When installing unit equipment with a battery backup, making sure the fixtures are fully charged and ready for final inspection is key.

Most unit equipment is shipped to the job site with the battery leads disconnected. The electrician installs the emergency lights and exit signs and generally leaves the batteries disconnected until a temporary power clearance is issued and the utility company sets a meter. When power is finally on, the electrician must remember to go back through the building and connect all battery leads in the emergency fixtures so they can charge for the final inspection.

Another common issue is emergency lighting installed to back up high intensity discharge (HID) lighting that provides normal area illumination. Metal halide is a type of HID luminaire that needs 5 to 15 minutes to warm up to full brightness. During a power outage, the HID fixture turns off and the battery backed emergency light adjacent to it takes over to give occupants enough emergency illumination to safely exit. If power comes back on, the emergency light senses power is present and shuts off. Now the space is left dark while the HID luminaire warms up to full brightness. Unless the HID fixture has an instant quartz restrike feature, the emergency light should have a time delay capability in order to stay illuminated, even after power is restored, until the HID fixture returns to full brightness.

Section 700.16: 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.

Question 41: Which of the following is required of emergency lighting?

A: It must operate after normal levels of illumination have been restored.
B: It must operate until normal illumination levels have been restored.
C: It must operate within 30 seconds of normal power loss.
D: It must illuminate before normal power it lost.

Question 42: 700.16 Emergency Illumination Part 2.

Question ID#: 10379.0

The circuit breaker for this emergency luminaire is currently 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 wouldn't leave this space in total darkness.

The term ***Emergency Illumination*** includes egress lighting, illuminated exit signs, and any other lights necessary to provide required illumination during an emergency. Building Code specifies the locations where emergency lighting and exit signs are required and how bright they must be, whereas the NEC provides the rules on how they must be connected and arranged to illuminate.

Section 700.16 requires the emergency lighting to be arranged 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. In short, if an area is required by the Building Code to have emergency lighting, then if the emergency luminaire's lamp burns out, there should be another emergency luminaire close enough (or possibly another lamp in the same fixture) that will ensure the area requiring the illumination is not left in total darkness.

The Code also states where the sole lighting (normal illumination, not the emergency lighting) is provided by high-intensity discharge (HID) fixtures (such as high/low pressure sodium, mercury vapor, metal halide, etc.) then the emergency illumination MUST STAY LIT until that HID illumination is restored. Meaning NOT just until the power kicks back on. Sometimes these HID fixtures can take minutes to heat back up and start producing light even after power is restored.

Many luminaires function to provide normal area lighting and also have a battery backup so they can double as an emergency light in the event of power loss. Often these luminaires have two or three lamps that operate on normal power but only one lamp may operate from the battery when normal power is lost. Strategic placement of these types of luminaires is crucial. If an area is required by the Building Code to have emergency lighting, and if only one of these types of luminaires is installed in the area, then Section 700.16 is violated. One of the two or three lamps in the fixture will operate in battery mode but if it burns out, the area requiring emergency lighting will now be left in total darkness. An adjacent luminaire should also have a battery backup so that it can also provide illumination if the other burns out.

Question 42: Which of the following emergency lighting configurations complies with NEC 700.16?

A: Two emergency lights, side by side, each having one lamp that operates from battery power when normal power is out.
B: One emergency light installed alone in an isolated area with only one lamp to illuminate.
C: A two-lamp luminaire installed alone in an isolated area where only one lamp illuminates from battery power when the normal power to the first lamp goes out.
D: A two-lamp emergency light where one lamp was removed to conserve energy.

Question 43: 110.3(B) Installation and Use.

Question ID#: 10380.0

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

The final inspection is the last inspection for a project and comes at a time when grand openings have been scheduled, products are being stocked, and new employees are being hired to prepare for opening day. A contractor will pay a big penalty for each day that a failed final inspection holds up the grand opening. As a project nears final, there is no extra time or money left for last minute surprises that the inspector might find. Being prepared is key.

At the final inspection, the inspector will verify that all equipment installed is suitable for the location and installed according to manufacturer's installation instructions.

Exterior emergency lights are often needed outside exit doors. This location could be considered a wet or a damp location depending on exposure. Many final inspections fail because a dry location fixture is installed in a damp or wet location.

- According to Article 100, a ***damp location*** is an area ***protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture***. Examples include partially protected locations under canopies, marquees, roofed open porches, and the like.
- A ***dry location*** is ***not normally subject to dampness or wetness***.
- ***Wet locations*** include electrical equipment ***in unprotected locations exposed to weather***.

Fortunately, luminaires are factory marked as to their intended location. This marking is required as part of the luminaire listing process and is considered part of the installation instructions.

410.10(A) Wet and Damp Locations: ***All luminaires installed in wet locations shall be marked, "Suitable for Wet Locations." All luminaires installed in damp locations shall be marked "Suitable for Wet Locations" or "Suitable for Damp Locations***."

110.3(B) Installation and Use: ***Listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling***.

Question 43: Which luminaire is installed in a damp location?

A: An exit sign installed in an office.
B: An exit sign installed in a bathroom.
C: An emergency light installed outside, under a roofed open porch.
D: An emergency light outside on an exterior wall, exposed to weather.

Question 44: 427.22 Pipelines and Vessels. Ground-Fault Protection of Equipment.

Question ID#: 10381.0

GFPE is required for pipeline heating, not GFCI protection.

Ground-fault circuit-interrupter (GFCI) protection for personnel is different than ground-fault protection for equipment (GFPE).GFCI protection monitors current leakage to ground and trips if those levels reach between 4 and 6 mA, which is well below heart fibrillation levels. GFPE, on the other hand, generally trips between 30 and 60 mA and can be set to significantly higher levels to afford special protection that certain equipment needs from ground-fault conditions that the overcurrent device ahead of the circuit may not notice. These higher GFPE levels may ensure equipment reliability but cannot be counted on for personnel protection since they trip at current leakage levels to ground that would be lethal to a person.

Ground-fault protection of equipment is defined in Article 100 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. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device***.

Section 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. A blocked, frozen condensate line will cause the refrigeration unit to shut off which can destroy thousands of dollars in frozen food, prescription drugs, chemicals, and the like. Using a GFCI device to protect the heat trace line instead of GFPE can cause nuisance tripping at low current levels which are harmless to the equipment being protected. The most common method to provide GFPE will be in the form of 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.

Question 44: Which of the following is true of GFPE?

A: It is a device that protects equipment from small ground-fault currents that the overcurrent device ahead of the circuit may not notice.
B: It is a device that protects personnel from small ground-fault currents that the overcurrent device ahead of the circuit may not notice.
C: It is a device that protects equipment from large ground-fault currents that are too big for the overcurrent device ahead of the circuit to handle.
D: It is a device that trips between 4 and 6 mA.

Question 45: Final Equipment Installation.

Question ID#: 10382.0

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

It would be foolish for the electrical inspector to give final approval on the job if there is still work left to be done after the inspection is over. When final inspection is requested by the contractor, all electrical work should be done with no work remaining. Many times, the electrician is pressured by the general contractor to call for final inspection even if the job is nowhere near ready for final. An electrical inspector who passes the job for final when there are still uninstalled/missing items or equipment shown on the plans will bear the full responsibility in the courtroom in the event that inadequate wiring methods to these items (installed after final inspection and never inspected) cause an injury to a patron.

When a set of plans is approved by the city plans examiner, it will be recorded and accessed in the future in the event that the inspector is taken to court over an injury. If there is equipment shown on the plans that has not yet been installed, and if it is not relevant to allowing occupancy, then the electrical contractor should obtain a separate permit for these insignificant items. The electrical wiring for this equipment can then be inspected at a later time from the new permit that was issued, and the main permit for final occupancy can be closed.

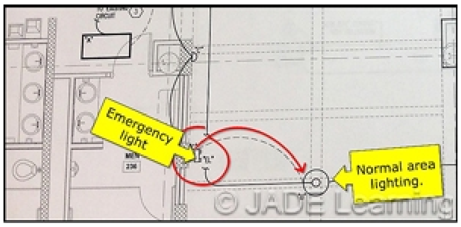
In some situations, a temporary certificate of occupancy can be given if there are no life safety related items or Code violations that still need correction. The business can then open and insignificant electrical items can be finished and inspected later from the original permit.

Question 45: Which of the following is true of the final electrical inspection?

A: The electrician is not responsible to go over any of the job to check for violations or work remaining.
B: The electrician should only have to fix what the inspector asks for and should not have to double check for anything that the inspector missed.
C: The city-approved plans should be discarded if equipment shown on the plans has not yet been installed.
D: All electrical work should be complete with no work remaining.

Question 46: 700.12(F)(2)(3) Unit Equipment.

Question ID#: 10383.0



The branch circuit feeding the unit equipment shall be the same branch circuit as that serving the normal lighting in the area.

Emergency lighting and exit signs are considered ***unit equipment*** and are covered in Article 700 for Emergency Systems. NEC 700.12(F)(2)(3) requires the branch circuit feeding the unit equipment to comply with the following:

- The unit equipment must be connected ahead of any local switches (on the line side of a switch).
- The unit equipment must be fed from the same branch circuit that serves the normal lighting in the area.

Connecting emergency illumination to the line side of a switch ensures that the unit equipment is not turned off along with the normal area lighting when a room or area is left unoccupied. The functioning of an emergency light or exit sign should not be dependent on which position a wall switch was left in.

Not all fires or disasters will knock out every circuit in a panelboard. Most catastrophes will occur in an isolated portion of a building and may only trip the circuit breakers serving that area. For this reason, emergency lighting and exit signs are required to be wired to normal area lighting that serves the area where the emergency lighting is located. If an emergency occurred that knocked out a specific roomâ€™s normal lighting, or if first responders shut off the power in the affected area as a precaution, the emergency lights and exit signs serving that room would sense the loss of normal power and be energized through a backup power source.

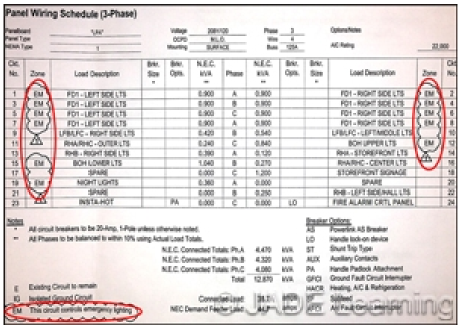
An exception allows emergency lighting to be on a different circuit from the normal area lighting for separate, uninterrupted areas supplied by at least three normal lighting circuits that are not part of a multiwire branch circuit. For these areas, a separate branch circuit for emergency illumination is allowed if it originates fromthe same panelboard as the normal lighting circuits and is provided with a lock-on feature.Â

Question 46: Which of the following is true if the normal area illumination in a small office is supplied from circuit number 17 in a panelboard?

A: The emergency lighting serving the office should also be tied into circuit 17 on the line side of the wall switch in the office.
B: Emergency lighting in an office should always be on a separate branch circuit.
C: The emergency lighting in the office should be supplied from a separate panelboard.
D: The exit signs outside of the office should also be tied into circuit 17 on the load side of the wall switch in that room.

Question 47: 700.12(F)(2)(4) Identification of Emergency Lighting Circuits.

Question ID#: 10384.0



Panel Wiring Schedule (3-Phase)

Panelboard "LFA" | Voltage 208Y/120 | Phase 3 | Options/Notes
Panel Type | OCPD M.L.O. | Wire 4
NEMA Type 1 | Mounting SURFACE | Bus 125A | A/C 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		10
11		RHA/RHC - OUTER LTS			0.240	C	0.840			BOH UPPER LTS	EM	12
13		RHB - RIGHT SIDE LTS			0.390	A	0.120			RHA - STOREFRONT LTS		14
15	EM	BOH LOWER LTS			1.040	B	0.270			RHA/RHC - CENTER LTS		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			RHB - LEFT SIDE/WALL LTS		22
23		INSTA-HOT		PA	0.000	C	0.000	LO		FIRE ALARM CRTL PANEL		24

Notes:
* All circuit breakers to be 20-Amp, 1-Pole unless otherwise noted.
** All Phases to be balanced to within 10% using Actual Load Totals.

N.E.C. Connected Totals: Ph.A 4.470 kVA
N.E.C. Connected Totals: Ph.B 4.320 kVA
N.E.C. Connected Totals: Ph.C 4.080 kVA
Total 12.870 kVA

Breaker Options:
AS Powerlink AS Breaker
LO Handle lock-on device
ST Shunt Trip Type
AUX Auxiliary Contacts
PA Handle Padlock Attachment
GFCI Ground Fault Circuit Interrupter
HACR Heating, A/C & Refrigeration
AFCI Arc Fault Circuit Interrupter

E Existing Circuit to remain
IG Isolated Ground Circuit
EM This circuit controls emergency lighting

Connected Load:
NEC Demand Feeder Load:

The branch circuit feeding the unit equipment shall be clearly identified at the distribution panel.

In large warehouses, it is quite common for the last one leaving to go out through the back door and turn off all circuit breakers in the panelboard that supply warehouse lighting. The practice of using the circuit breakers as switches is allowed by NEC 240.83(D) as long as the circuit breakers serving the lighting are marked "SWD" or "HID", depending on the type of lighting being switched on and off.

Emergency lighting and exit signs are often equipped with internal battery packs that provide 90 minutes of illumination if the power goes out during an emergency. The 90 minute duration allows for people to safely exit the building to a public way as required in the Building Code. If the emergency lighting is not properly identified on the panel directory, the person switching off all of the circuit breakers at the end of each day might inadvertently switch off the emergency lighting circuit also. It only takes about a week of being switched off every night and discharging the batteries on a daily basis before the batteries are shot and no longer able to provide 90 minutes of backup power in the event of a true emergency.

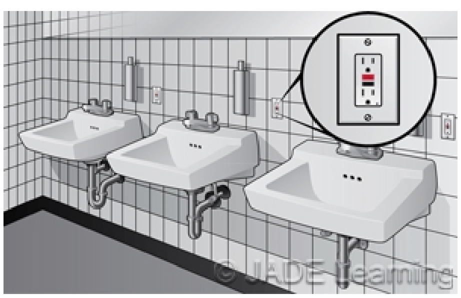
Emergency lighting and exit signs (unit equipment) are required to be clearly identified in the panelboard that supplies them. Properly identifying these circuits ensures that they will remain energized and fully charged at all times.

Question 47: Which of the following is an example of the proper way to identify a circuit in a panel that supplies normal area lighting and emergency lighting?

A: "Lights".
B: "Conference room 105".
C: "Conference room 105 lights/emergency lights".
D: "Conference room 105 lights".

Question 48: 210.8 GFCI Protection for Personnel.

Question ID#: 10385.0



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

Devices providing ground-fault circuit-interrupter (GFCI) protection must be readily accessible. Readily accessible means***capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to actions such as to use tools, to climb over or remove obstacles, or to resort to portable ladders, and so forth.***

GFCI protection is required for certain receptacles in order to protect the user from a shock that can occur from something that the user might plug into the receptacle. This can be accomplished by using a GFCI-type receptacle or a GFCI type circuit breaker.

GFCI protection is also required for specific appliances, motors, or luminaires regardless of how they are connected. This can be through a receptacle or a hard-wired connection. The most common way to provide GFCI protection for hard-wired equipment is to use a GFCI-type circuit breaker ahead of the circuit.

The following locations are required to have GFCI protection for the receptacles. This applies to 15- and 20-ampere single-phase 125-volt receptacles serving:

- A dwelling unit kitchen counter
- Crawl spaces
- Unfinished basements
- Boathouses
- Within 6 ft. of a bathtub or shower stall
- Dwelling unit laundry areas

- Bathrooms (all occupancies)
- Kitchens (other than dwellings)
- Rooftops
- Outdoors
- Within 6 ft. of any sink
- Indoor wet locations
- Locker rooms with showers
- Garages, service bays
- Elevator pits and machine rooms.

The following items are required to have GFCI protection whether cord-and-plug connected or hard-wired. The GFCI protection requirements for all but the last item listed below are NOT voltage specific:

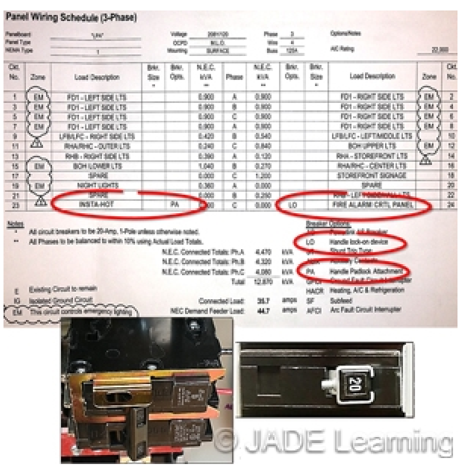
- Kitchen dishwasher outlets
- Vending machines
- Electric drinking fountains
- Tire inflation machines and automotive vacuum machines provided for public use
- Floor heating cables
- Most underwater pool luminaires
- Spas and hot tubs
- Single-phase, 120-240 volt pool pump motors.

Question 48:   Which of the following is true of a GFCI-type device?

A: It can be located where it can only be reached by a portable ladder.
B: It can only be a receptacle.
C: It can only be a circuit breaker.
D: It is not permitted to be blocked by a heavy appliance.

Question 49:   110.25 Lockable and Lock-on Type Devices.

Question ID#: 10386.0



Lockable devices and lock-on type devices serve different purposes.

During the final inspection, the inspector will be verifying the presence of any lockable or lock-on type devices at the panelboard. Below are examples of Code sections in the NEC that specify the use of one or the other:

422.31(B) Appliances Rated Over 300 Volt-Amperes. For permanently connected appliances rated over 300 VA, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means where the switch or circuit breaker is within sight from the appliance or is lockable in accordance with 110.25. For example, a non-motor appliance, such as a water heater or cooktop, is not required to have a disconnecting means within sight of the appliance if the circuit breaker supplying it is lockable and the provisions for locking it remain in place with or without the lock installed as mentioned in 110.25.

700.12(F)(2)(3) Exception. In a separate and uninterrupted area supplied by a minimum of three normal lighting circuits that are not part of a multiwire branch circuit, a separate branch circuit for unit equipment shall be permitted if it originates from the same panelboard as that of the normal lighting circuits and is provided with a lock-on feature.

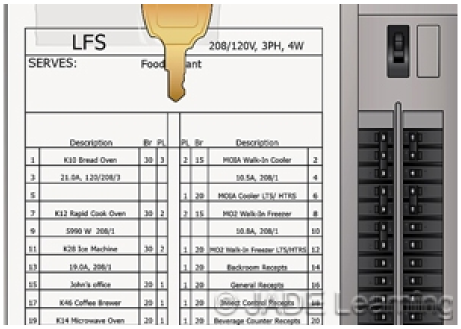
As well, the fire inspector may also ask for a lock-on type device for the circuit that supplies the fire alarm control panel. Lock-on type devices ensure that certain important circuits remain energized. Lock-on type devices do not interfere with the functioning of a circuit breaker. As part of the listing process, circuit breakers are required to be able to interrupt a fault condition regardless of switch handle position.

Question 49: Refer to the image. Which of the following circuits requires a lockable type device if a local disconnect is not installed?

A: Circuit 18.
B: Circuit 19.
C: Circuit 21.
D: Circuit 23.

Question 50: 408.4(A) Circuit Directory.

Question ID#: 10387.0



The circuits must be legible, evident to the specific purpose, and cannot depend on transient conditions of occupancy.

During the final inspection, the inspector will be looking at the panel circuit directory or panel schedule for accuracy. Many inspectors will not allow a handwritten panel schedule. What may be legible to one person may not be legible to another. Using typed panel schedules ensures that everyone can understand it. The following requirements come from Section 408.4(A).

- ***Every circuit and circuit modification shall be legibly identified as to its clear, evident, and specific purpose or use.***
- ***The identification shall include an approved degree of detail that allows each circuit to be distinguished from all others.***
- ***Spare positions that contain unused overcurrent devices or switches shall be described accordingly.***
- ***The identification shall be included in a circuit directory that is located on the face or inside of the panel door in the case of a panelboard and at each switch or circuit breaker in a switchboard or switchgear.***
- ***No circuit shall be described in a manner that depends on transient conditions of occupancy.***

The first and last bullet point listed above are especially important. The circuits must be legible, evident to the specific purpose, and cannot depend on transient conditions of occupancy. In other words, the identification cannot depend on who may be occupying a space within the building now but may not be a year from now.

Question 50: Refer to the image. Which of the following circuits is dependent on transient conditions of occupancy?

A: Circuit 15.
B: Circuit 11.
C: Circuit 14.
D: Circuit 12.

Answer Sheet

Darken the correct answer. Sample: A ● C D

VA Installation Checklists   Course# 2731002702   3 Code Credit Hours $50.00

1.) A B C D	**18.) A B C D**	**35.) A B C D**
2.) A B C D	**19.) A B C D**	**36.) A B C D**
3.) A B C D	**20.) A B C D**	**37.) A B C D**
4.) A B C D	**21.) A B C D**	**38.) A B C D**
5.) A B C D	**22.) A B C D**	**39.) A B C D**
6.) A B C D	**23.) A B C D**	**40.) A B C D**
7.) A B C D	**24.) A B C D**	**41.) A B C D**
8.) A B C D	**25.) A B C D**	**42.) A B C D**
9.) A B C D	**26.) A B C D**	**43.) A B C D**
10.) A B C D	**27.) A B C D**	**44.) A B C D**
11.) A B C D	**28.) A B C D**	**45.) A B C D**
12.) A B C D	**29.) A B C D**	**46.) A B C D**
13.) A B C D	**30.) A B C D**	**47.) A B C D**
14.) A B C D	**31.) A B C D**	**48.) A B C D**
15.) A B C D	**32.) A B C D**	**49.) A B C D**
16.) A B C D	**33.) A B C D**	**50.) A B C D**
17.) A B C D	**34.) A B C D**	

Please fill out the following information and mail this answer sheet along with payment to:
JADE Learning 225 E Robinson St #570, Orlando, FL 32801
Phone: 1 (800) 443-5233
This course is $50.00
We accept: checks, cash, money orders, credit or debit cards. Visa, MasterCard, AMEX or Discover.

Name ______________________________ VA License #______________________

Mailing Address ______________________________ Phone ____________________

City, State, Zip Code ____

Credit Card Number ______________________________ Expiration Date ____________

Email Address ____