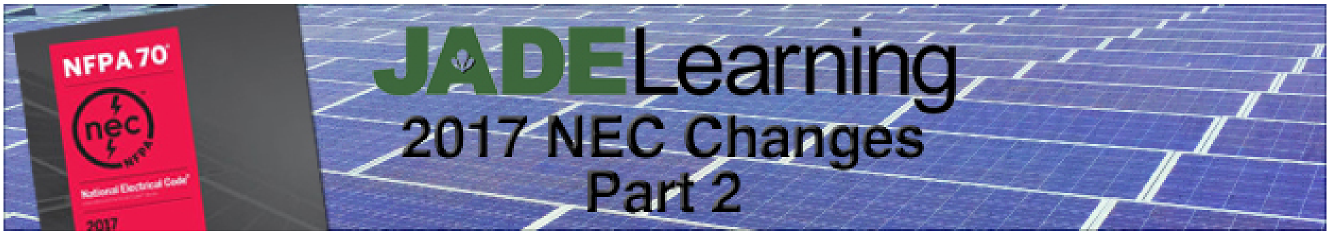


2017 NEC Changes Part 2 (Homestudy)

Alaska Electrical License

This course will review the second half of the most important National Electrical Code changes from the 2017 NEC. Changes from Articles 409 - Informative Annex D will be covered.

Course# 15669 8 NEC Credit Hours $90.00

This course is currently approved by the Alaska Division of Labor Standards and Safety, Mechanical Inspection under course number 15669.

Completion of this continuing education course will satisfy 8.000 credit hours of course credit type 'NEC' for Electrical license renewal in the state of Alaska. Course credit type 'NEC'. Board issued approval date: 1/23/2018. Board issued expiration date: 12/31/2019.

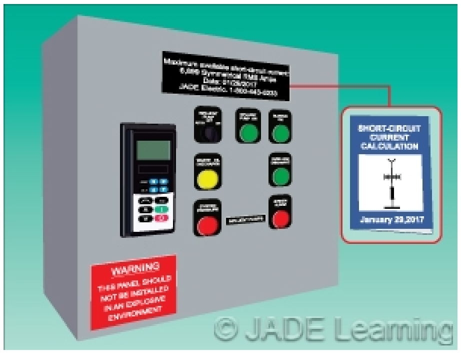
JADELearning

2017 NEC Changes Part 2 (Homestudy) - AK

Chapter 4

Question 1: 409.22 Industrial Control Panels. Short-Circuit Current Rating.

Question ID#: 1150.0



An industrial control panel cannot be installed where the available short-circuit current is greater than the short-circuit current rating. A record of the available short-circuit current and the date of the calculation must be kept.

This section was revised to refer to "short-circuit current" rather than "fault current," and a new rule about documentation was added. Section 409.22(A) is now titled "Installation" and says an industrial control panel cannot be installed where the available short-circuit current exceeds it short-circuit current rating.

A new 409.22(B) is titled "Documentation" and requires a record to be kept of the calculation of the available short-circuit current along with the date of the calculation. The calculated available short-circuit current is not required to be marked on the industrial control panel but must be available for inspection.

Documentation of the calculated short-circuit current is only required if the industrial control panel is required to be marked with a short-circuit current rating. Industrial control panels are not required to be marked with a short-circuit current rating if they only contain control circuit components where available short-circuit currents would be relatively low.

The change from fault current to short-circuit current is part of a larger code-wide effort to provide consistent terminology. Short-circuit current can be safely substituted for fault-current in almost any situation, but the opposite may not be true. For example, short-circuit current will usually be greater than ground-fault current simply because short-circuit voltages between ungrounded conductors are usually higher than voltages to ground.

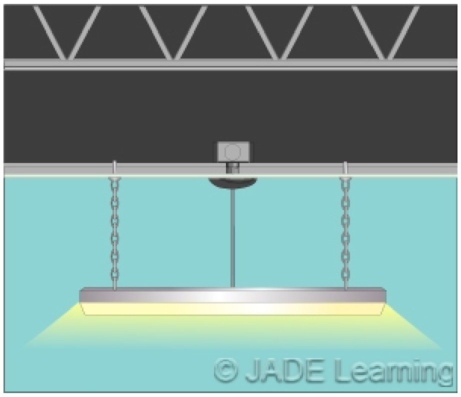
Under these new rules it should be easier for an installer to ensure that the code will not be violated by being able to compare the marked short-circuit current rating on an industrial control panel to the documented available short-circuit current. The NEC only requires the documentation to be available for inspection, but if the documentation exists, installers and designers can also request the information.

Question 1: Which of the following is a requirement for industrial control panels?

A: All industrial control panels must be marked with the calculated available short-circuit current.
B: All industrial control panels are required to be marked with a short-circuit current rating.
C: If an industrial control panel is required to have a short-circuit current marking, the available short-circuit current must be documented.
D: Documentation is not required if the short-circuit current is marked on the industrial control panel.

Question 2: 410.62(C) Cord-Connected Lampholders and Luminaires. Electric-Discharge and LED Luminaires.

Question ID#: 1151.0



A luminaire equipped with a strain relief and canopy is permitted to include a section of raceway not over 6 in. in length to attach to an outlet box above a suspended ceiling.

Section 410.62(C)(1) has been reorganized to make it easier to understand. The rules for cord connecting electric-discharge and LED luminaires are otherwise unchanged.

In order to be cord connected, a luminaire must be located directly below the lighting outlet or busway outlet to which the luminaire is connected, and the cord must not be subject to any type of physical damage or strain. The cord must also be visible for its entire length, except for terminations made inside the outlet box. Other than utilizing the 6 in. raceway that is allowed for a luminaire equipped with a strain relief and a canopy, luminaire cords are not permitted to extend at all above a suspended ceiling. Note, Section 410.62(C)(1)(b) says "The canopy shall be permitted to include a section of raceway not over 6 inches in length...". This is important to know because increasing the length of the conduit to protect the cord is not allowed when trying to remedy a junction box that is too far away from the luminaire. So traveling the length of the 6 in. raceway (which protects the cord) to reach an outlet box above a suspended ceiling is permitted, but traveling any further than 6 in. above a ceiling is not.

CORD AND PLUG: A luminaire is permitted to be cord-and-plug connected using grounding-type attachment plugs, or the cord may be connected directly to a lighting outlet junction box. Manufactured wiring system connectors are permitted for listed luminaires and assemblies that are covered by 604.100(C).

CORD THAT IS PART OF A LISTED LUMINAIRE: It is permissible to use a cord between luminaire and canopy, that is part of a listed luminaire assembly. This listed luminaire assembly must be equipped with strain relief to support the weight of the assembly, independent of the wiring terminations. That strain relief and canopy can include a (maximum) 6 in. long raceway to enable connection to a junction box above the suspended ceiling. But as stated earlier, in no case can the raceway between the canopy and the outlet box be longer than 6 in above the ceiling, if it is to house a luminaire cord above the ceiling.

Other than as modified by this Code-section, flexible cord is not permitted by NEC 400.12, to be installed in the space above a suspended ceiling.

Question 2: A listed cord-connected LED luminaire is equipped with a canopy and a 6-in. long raceway, but the closest outlet box to which it can connect to is 18 in. above a suspended ceiling. Which of these actions must be taken to meet Code?

A: A grounding-type receptacle must be installed above the suspended ceiling.
B: No more than 1 ft. of cord is permitted in the space above the ceiling.
C: The outlet box must be relocated to within reach of the 6" raceway.
D: A canopy equipped with an 18-in. long raceway must be installed.

Question 3: Article 411 Low-Voltage Lighting.

Question ID#: 1152.0

Low voltage systems that use insulated conductors can be made up of listed components and do not need to be listed as a complete system.

Article 411, Low Voltage Lighting, now restricts output voltages to 30 volts ac or 60 volts dc. Where wet contact is likely to occur, the voltage limits are 15 volts ac or 30 volts dc.

The reference to Class-2 power sources in the title of the Article was deleted because a Class-2 power source at 60 volts dc is limited to an output of 100VA, or 1.7 amps. Most low voltage lighting systems require more than 1.7 amps.

Section 411.4(A) was revised to exclude systems with insulated conductors from the requirement that "***lighting systems operating at 30 volts or less shall be listed as a complete system."*** In the 2014 NEC, Section 411.4(A) conflicted with Section 411.4(B) that allows a lighting system to consist of separate listed parts. The new wording clarifies that systems with bare conductors must be listed as complete systems, but systems with insulated conductors may consist of separate listed parts. The revised rules in Article 411 are straightforward:

1. Low voltage systems are limited to 30 volts AC and 60 volts DC unless wet contact is likely to occur where the voltages are 15 volts AC and 30 volts DC.

2. The maximum current output of a power supply is 25 amps.

3. Bare conductor systems must be listed as a complete system and insulated conductor systems may be made up of listed components.

Question 3: What is the maximum output voltage for an AC low voltage lighting source?

A: 12 volts.
B: 30 volts.
C: 60 volts.
D: 24 volts.

Question 4: 422.5 Appliances. GFCI Protection for Personnel.

Question ID#: 1153.0

The appliances listed in this section which are rated 250 volts or less and 60 amperes or less, single- or 3-phase, must have GFCI protection for personnel.

This section was revised to relocate and consolidate the requirements for GFCI protection for various types of appliances.Â The rules were previously located in different sections of Article 422.Â The requirements for ready access to the GFCI device were also revised to provide for multiple locations that would be permissible for the GFCI protective device required for appliances. A listed GFCI can be in any of the locations specified as long as it is readily accessible. The change does not add any new appliances to the list of appliances formerly requiring GFCI protection. However, it does expand the range of voltage systems and current ratings of appliances that require GFCI protection.

The list of appliances in this section includes automotive vacuum machines provided for public use, drinking water coolers, tire inflation machines provided for public use, and vending machines, as well as the high-pressure spray washing machines.Â Any of these appliances require GFCI protection if they are rated 250 volts or less and 60 amperes or less, single or 3-phase.

Boat hoists and dishwashers are not included in the list, but GFCI protection for boat hoists and dishwashers is required in dwelling unit locations, per 210.8(C)&(D).

The previous requirement that the device providing GFCI protection be readily accessible now provides for a variety of locations where the devices may be located as long as it is readily accessible.Â One or more devices are permitted to provide GFCI protection.Â For any of the appliances in the list the protective device is permitted to be within the branch circuit overcurrent device, elsewhere within the supply circuit, integral to the attachment plug, in the supply cord if within 12 inches or 300 mm of the attachment plug, or factory installed within the appliance.Â Â

Question 4: Section 422.5 requires which one of the following appliances to have GFCI protection?

A: Tire inflation machines in a private garage.
B: Tire inflation machines intended for public use.
C: A 30 ampere, 208 volt air compressor.
D: A 20 amp 240-volt portable air compressor.

Question 5: 422.6 Appliances. Listing Required.

Question ID#: 1154.0

Appliances must now be listed and installed according to their listing.

New NEC Section 422.6 requires all appliances operating at 50 volts or more to be listed. Previous editions of the NEC had no listing requirement for appliances.

The NEC does not require all equipment and conductors to be listed. Section 110.2 only requires that all conductors and equipment be "***approved".*** Equipment does not have to be listed unless the NEC specifically says that a particular type of equipment must be listed. For example Section 352.6 requires that all PVC conduit, factory elbows, and associated fittings are to be listed. If listing is not required for a particular wiring method or piece of equipment it is up to the AHJ to approve it. (or not approve it)

The 2014 NEC did not require appliances to be listed as a general rule but there are several places in article 422 where the terms "listed" or "listing" are used. For example Section 422.15 gives rules on installing "***Listed central vacuum outlet assemblies".***

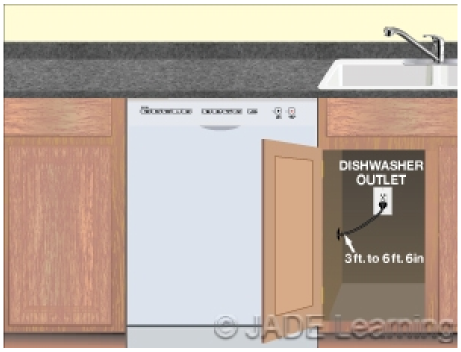
NEC Section 110.3(b) requires that equipment must be installed and used in accordance with its listing or labeling if it has been listed. Requiring that appliances operating at 50 volts or more are listed will insure that these appliances will be installed according to the manufacturer's instructions.

Question 5: Which appliances must be listed?

A: All appliances except those in dwelling units.
B: Only appliances installed in non-dwelling units.
C: Appliances operating at 50 volts or more.
D: All appliances.

Question 6: 422.16(B)(2) Flexible Cords. Specific Appliances. Built-in Dishwashers and Trash Compactors.

Question ID#: 1155.0



A receptacle for the dishwasher is no longer permitted to be installed behind the dishwasher. The receptacle must be accessible.

This revision changes the requirements for built-in dishwashers and trash compactors connected with flexible cords. The permitted locations of receptacles and lengths of cords for connecting trash compactors are now different from those for dishwashers.

The permitted length of a cord for a trash compactor remains the same (3 ft. to 4 ft.) and is still measured from the face of the attachment plug to the plane of the rear of the appliance. The receptacle location for a trash compactor also remains the same: either in the space occupied by the trash compactor or immediately adjacent to that space.

The permitted length of a cord for a dishwasher is now 3 ft. to 6.5 ft (6 ft. 6 inches). The location of the receptacle has also changed. It is now required to be in the space adjacent to the space where the dishwasher is installed. The receptacle is no longer permitted to be installed behind the dishwasher. The longer cord is permitted to accommodate the required location of the receptacle and the location of the receptacle is required to meet listing requirements for the installation of listed dishwashers. The new requirement in 422.6 requires the dishwasher to be listed.

In either case, the receptacle must be accessible. However, the dishwasher is also required by 210.8(D) to be protected by a GFCI device. If a GFCI receptacle is used for this purpose it must be readily accessible, not just accessible. Typically the receptacle would now be installed in the base cabinet under the sink, but that space would have to be kept relatively clear in order for the GFCI receptacle to be readily accessible as defined in Article 100. An alternative would be to provide the GFCI protection in the circuit breaker protecting the branch circuit or by providing a separate GFCI device without receptacles in a readily accessible location.

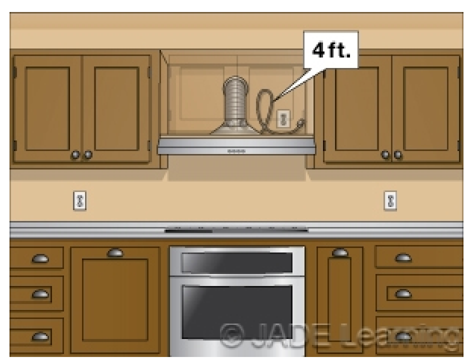
Question 6: Where is the receptacle for a dishwasher required to be installed?

A: In the space adjacent to the dishwasher.
B: In the space behind the dishwasher.
C: In the countertop above the dishwasher.
D: No closer than 8 ft. from the dishwasher.

Question 7: 422.16(B)(4) Flexible Cords. Specific Appliances. Range Hoods.

Question ID#: 1156.0

Kitchens are a major feature in any home and appliances make the kitchen. Kitchen ranges are available from the old standard 30 in. width to 60 in. wide or more. A big range needs a big range hood.



The maximum length of the cord for a range hood has been increased.

Many manufacturer's installation instructions allow the range hood to be cord and plug connected. The receptacle is typically located in a cabinet directly above the range hood, but with the increasing width and depth of range hoods the 3 ft. of flexible cord allowed by the 2014 NEC may not reach the receptacle. The 2017 NEC has increased the maximum length of flexible cord allowed for connection of range hoods from 3 ft. to 4 ft.

Several conditions apply when using flexible cord to connect a range hood. First, the hood manufacturer's installation instructions must identify the type of flexible cord suitable for connecting the range hood. In section 422.16(B)(4) the NEC provides five additional requirements:

- ***The flexible cord is terminated with a grounding-type attachment plug.***

- ***<u>The length of the cord is not less than 18 in. and not over 4 ft.</u>***
- ***<u>Receptacles are located to protect against physical damage to the flexible cord.</u>***
- ***<u>The receptacle is accessible.</u>***
- ***<u>The receptacle is supplied by an individual branch circuit.</u>***

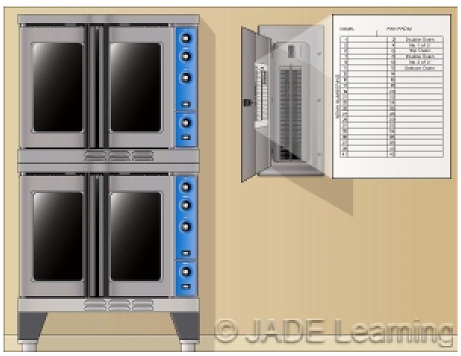
A cord-and-plug connection provides the appliance disconnect required by Article 422 and allows the range hood to be easily disconnected for cleaning or repair. Increasing the maximum length of the cord to 4 ft. will make it easier to connect the large range hoods installed in houses today.

Question 7: What is the maximum length cord permitted to connect a 60 in. wide range hood?

A: A suitable flexible cord not over 60 in. long.
B: A suitable flexible cord not over 48 in. long.
C: A suitable flexible cord not less than 12 in. nor more than 36 in. long.
D: A suitable flexible cord not less than the width of the range hood.

Question 8: 422.30 Appliances. Disconnecting Means. General.

Question ID#: 1157.0



<u>The disconnecting means for an appliance supplied by more than one branch circuit must be grouped and identified as being the multiple disconnecting means for the appliance.</u>

Multiple disconnecting means for a single appliance supplied by more than one circuit must now be grouped and identified.

The ability to de-energize an electrical appliance is essential for a technician to safely service or repair the appliance. Unit switches without a marked OFF position or that do not open all ungrounded supply conductors cannot serve as the required disconnecting means.

The 2017 NEC requires that the disconnecting means for an appliance supplied by more than one branch circuit or feeder be, "grouped and identified as being the multiple disconnecting means for the appliance," (422.30). Each disconnecting means must simultaneously disconnect all ungrounded conductors it controls, but is not required to disconnect the other circuit(s) supplying the appliance. Grouping the disconnects will enable a service technician to clearly identify and open all of the disconnects supplying a specific appliance.

For example, a double oven in a restaurant is supplied by two, 208-volt, 40-amp branch circuits installed in liquidtight flexible metallic conduit. Two 40-amp branch circuit breakers are located in a 42-circuit panelboard within sight of the double oven. The circuit breakers should be legibly marked for the oven that they supply, but must also be labeled to indicate that the two circuit breakers serve as the multiple disconnecting means for the same appliance.

The two 40-amp circuit breakers should be grouped adjacent to each other in the panelboard. If one breaker is at the top left of a 42-circuit panelboard and the other is at the bottom right, the authority having jurisdiction may question that the disconnecting means are grouped as required by section 422.30. If an appliance is supplied by individual disconnects in separate enclosures, the enclosures must be grouped and identified as the multiple disconnecting means for the same appliance.

Question 8: A commercial dishwasher is supplied by two 30-amp branch circuits. Which of the following statements about the disconnecting means for the dishwasher is true?

A: There must be a single disconnect that simultaneously opens both circuits.
B: Two disconnecting means are allowed in two different locations if both are capable of being locked in the open position.
C: Two disconnecting means are allowed if grouped and identified as the multiple disconnecting means for the dishwasher.
D: Unit switches that do not open all ungrounded conductors can serve as the appliance disconnecting means.

Question 9: 422.31(A) Disconnection of Permanently Connected Appliances. Rated at Not over 300 Volt-Amperes or 1/8 Horsepower.

Question ID#: 1158.0

The disconnecting means for appliances that are rated not more than 300 volt-amperes or 1/8 HP must be within sight of the appliance or have a lockout device on the circuit breaker.

Small permanently connected appliances rated not over 300 volt-ampere or 1/8 HP must now either have a disconnecting means within sight of the appliance or the branch circuit overcurrent device must be capable of being locked in the open position. Many bathroom exhaust fans and attic exhaust fans will fall under the new requirement.

The shock hazard present when repairing or replacing an appliance connected to a 120-volt 15- or 20-amp branch circuit is essentially the same regardless of the rating of the appliance. Small appliances such as bathroom exhaust fans rated not over 300 volt-amps or 1/8 HP are often connected to multi-outlet branch circuits that serve other lighting and or receptacle loads. If the branch circuit breaker is the only disconnecting means, it must be capable of being locked in the open position to prevent someone attempting to restore power to these other loads while the appliance is being worked on.

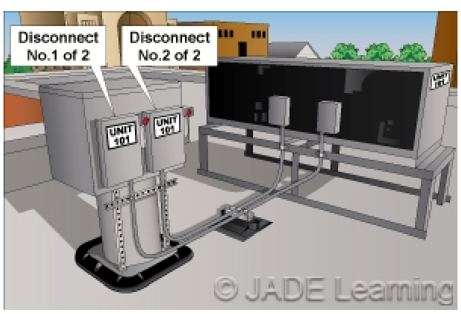
A unit switch on the appliance with a marked-OFF position and that disconnects all ungrounded conductors can serve as the appliance disconnecting means, but with electronic controls it is not always easy to tell when the switch is on or off. Many decorative wall switches do not have a marked-OFF position. The simple solution is to provide a lock-out device on the branch circuit breaker supplying the appliance(s). The lock-out device used on the branch circuit breaker must meet the lockable requirements in 110.25 and must remain in place with or without a lock installed.

Question 9: A 1/10 HP through-the-wall kitchen exhaust fan is installed over a range. Which of the following is permitted to serve as the required disconnecting means?

A: A pull chain operated snap switch on the fan.
B: A 15-amp branch circuit breaker that is lockable in accordance with 110.25.
C: A 15-amp branch circuit breaker with a lock out device that remains in place only when the lock is installed.
D: A wall switch without a marked-OFF position on the wall next to the fan.

Question 10: 424.19 Control and Protection of Fixed Electric Space-Heating Equipment. Disconnecting Means.

Question ID#: 1159.0



Multiple disconnects for heating equipment must be grouped and identified as being a part of multiple disconnecting means.

If heating equipment is supplied by more than one branch circuit or feeder, each disconnecting means for the equipment must be grouped and ***"identified as having multiple disconnecting means,"*** (424.19). It is essential that a service technician be able to locate and disconnect all circuits supplying a heating unit in order to safely work on the equipment. The disconnecting means for each branch circuit or feeder must simultaneously disconnect all of the ungrounded conductors it supplies, but is not required to disconnect the other circuit(s) supplying the heating equipment. This is one reason the disconnects must be grouped and identified.

The 2014 NEC required the disconnecting means for all circuits supplying the same heating equipment to be "***grouped and marked."*** The 2017 NEC language,***" grouped and identified as the multiple disconnecting means,"*** should make it easier to recognize when multiple circuits supply the same equipment.

For example, the disconnects for several rooftop units may be grouped adjacent to an auxiliary gutter in order to comply with the tap conductor rules in Article 240. The disconnects are grouped and marked, but a service technician can easily miss the fact that two or more of the disconnects supply the same heating unit. All of the disconnecting means supplying a single heating unit must now be identified in a way that will inform the service technician that there are multiple disconnecting means for the unit. The disconnects for all circuits supplying the unit must be both grouped and identified as the multiple disconnecting means for the heating equipment.

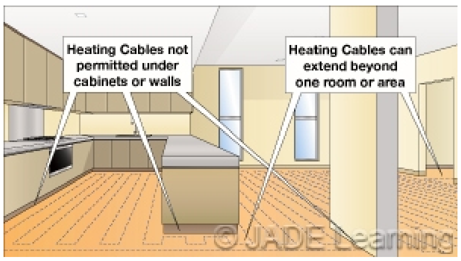
Each disconnect serving as the multiple disconnecting means is also required to be lockable in accordance with 110.25.

Question 10: A rooftop heating unit is supplied by one 480-volt feeder and one 120-volt branch circuit. Which of the following statements about the disconnecting means is true?

A: Only the 480 volt disconnecting means is required to be lockable.
B: The two disconnecting means are not required to be grouped if the location of the disconnecting means is marked on the heating equipment.
C: The disconnecting means shall be grouped and identified as the multiple disconnecting means.
D: The disconnects shall be identified as multiple disconnecting means, but are not required to be grouped.

Question 11: 424.38 Electric Space-Heating Cables. Area Restrictions.

Question ID#: 1160.0



Heating cables are now permitted to extend beyond one room or area.

Heating cables are now permitted to extend beyond one room or area. This is a major change and recognizes improvements in heating cable technology and product standards.

For example, the new language will allow electric space-heating cables to be installed in a bath area and adjoining water closet area that share a continuous floor construction. In earlier codes these two areas could have been seen as separate rooms requiring the separation of the heating cables.

The heating cable must be routed to avoid the locations where heating cables are not permitted by 424.38(B).

The locations where heating cables are not permitted to be installed has been revised and expanded to clear up inconsistencies between the requirements for heating cables installed in floors and heating cables installed in ceilings. There are now 7 specific locations where heating cable is ***not*** permitted to be installed:

- ***In closets, other than as noted in 424.38(C). (REVISED)***
- ***Over the top of walls where the wall intersects the ceiling. (REVISED)***
- ***Over partitions that extend to the ceiling, unless they are isolated single runs of embedded cable.***
- ***Under or through walls. (NEW)***
- ***Over cabinets whose clearance from the ceiling is less than the minimum horizontal dimension of the cabinet to the nearest cabinet edge that is open to the room or area.***
- ***In tub and shower walls. (NEW)***
- ***Under cabinets or similar built-ins having no clearance to the floor. (NEW)***

Heating cables are not permitted to be run where heat build-up could create a fire hazard. Low-temperature heating cables are permitted in closet ceilings only for the control of relative humidity, not for comfort heating. The low temperature heating cables are permitted only in portions of the closet ceiling that are unobstructed to the floor by shelves or luminaires. Heating cables are not permitted to be installed in the floor of a closet.

Running heating cables under or through walls, or over the top of a wall that extends to the ceiling could entrap heat and create a fire hazard.

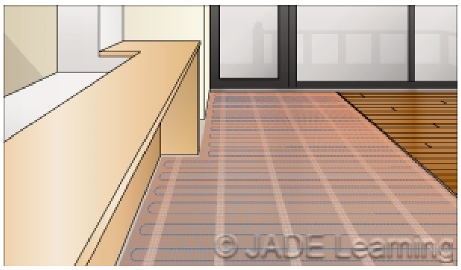
Heating cables are not permitted in tub or shower walls. Heating cables installed in tub or shower walls may be damaged by modifications to the tub or shower walls, such as the installation of a grab bar. A damaged heating cable could create a shock hazard to someone using the tub or shower.

Question 11: In which of the following bathroom locations is heating cable permitted?

A: In shower walls if listed for the purpose.
B: In the floor around the water closet.
C: In the walls around the bath tub.
D: Extending under the wall into an adjacent area with a bathroom sink.

Question 12: 424.45 Electric Space-Heating Cables. Installation of Cables Under Floor Coverings.

Question ID#: 1161.0



Electric space-heating cables can be installed below ceramic tile, hardwood, vinyl floor coverings or even carpet if installed according to the manufacturer's instructions and identified as suitable for use under the floor covering.

In recent years a number of new electric space-heating cable products have entered the market which do not have to be embedded in concrete. Electric space-heating cables are available that can be installed below ceramic tile, hardwood, vinyl floor coverings or even carpet. Heating cables are available in both line voltage and low voltage configurations from various manufacturers. Although many of these products have been evaluated by third party testing agencies, until now there have been no requirements in the NEC covering the installation of electric space-heating cables installed directly under floor coverings.

Heating cables installed under floor coverings must be installed in accordance with the manufacturer's instructions and must be identified as suitable for use under the specific type of floor covering. A heating cable that is designed for use in concrete would create a fire hazard if installed directly under a hardwood floor or in contact with carpet. The heating cable must also be provided with a grounding means such as a metal mesh or copper braid for the entire heated length of the cable and the cable must be GFCI protected. The cables must be secured in place below the floor covering in accordance with the manufacturer's instructions. If the cable crosses any expansion joints, special expansion and contraction fittings ***applicable to the manufacture of the cable*** are required (424.45(B)).

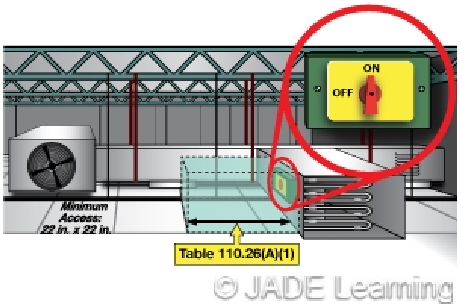
The new products add a great deal of flexibility to the installation of electric space-heating cables in floors. These products are relatively easy to install, but must be installed in accordance with the manufacturer's instructions and the new NEC requirements to ensure that the installation does not create a fire or shock hazard.

Question 12: An electric space-heating cable is identified for use under 3/4 in. hardwood floor covering. Which of the following statements about the heating cable is true?

A: The heating cable can be installed below carpet.
B: The heating cable is not required to be GFCI protected.
C: The heating cable is not required to be grounded.
D: The heating cable must be secured in place per the manufacturer's instructions.

Question 13:   424.66 Duct Heaters. Installation.

Question ID#: 1162.0



Duct heaters require working space in areas with limited access.

The limited access working clearance requirements specific to duct heaters installed above ceilings have been deleted, but this does not mean that working clearance is not required for duct heaters. The limited access requirements for electrical equipment rated 1000 volts or less, have been relocated to a new section in Article 110. Safe access is needed to any electrical equipment that is likely to require inspection or service while energized, not just duct heaters installed above ceilings. Duct heaters will now have to meet the same access requirements in section 110.26(A)(4) as other electrical equipment installed in spaces with limited access.

An access opening not less than 22 in. X 22 in. must be provided for duct heaters or other equipment installed above a lay-in ceiling. If the duct heater is installed in a crawl space, a 22 in. X 30 in. access opening is required. In all cases the width of the working space in front of the equipment shall not be less than 30 in. or the width of the equipment enclosure, whichever is greater. Hinged covers must be able to be opened to at least 90o and the depth of the working space in front of the enclosure must comply with depth requirements in Table 110.26(A)(1).

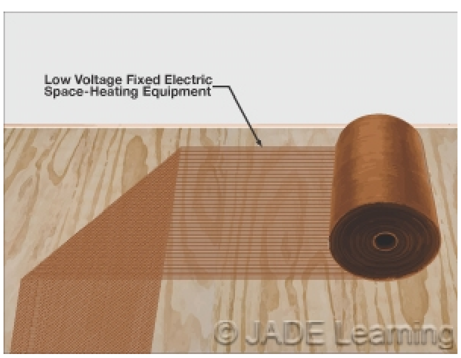
Moving the access requirements to Article 110 improves consistency in the NEC by requiring the same access requirements for all electrical equipment installed above ceilings or in crawlspaces, including duct heaters.

Question 13:   A duct heater in a 36 in. wide enclosure is installed above a lay-in ceiling. What is the minimum width of the working space in front of the duct heater?

A: 30 in.
B: 16 in.
C: 36 in.
D: 24 in.

Question 14:   424 Part X Low-Voltage Fixed Electric Space-Heating Equipment.

Question ID#: 1163.0



Low-voltage fixed electric space-heating equipment must be listed as a complete system and installed in accordance with the manufacturer's installation instructions.

Part X of Article 424 provides minimum requirements for low-voltage fixed electric space-heating equipment. Both low-voltage electric radiant heating panels and low voltage heating cables are currently on the market and being installed, but until now there have been no specific installation requirements in the NEC for this equipment.

Low-voltage fixed electric space-heating equipment must be listed as a complete system and installed in accordance with the manufacturer's installation instructions. It is not permitted to mix components from different low-voltage heating systems to create an unlisted system. A listed low-voltage electric space-heating system includes an isolating power supply, low-voltage heaters, and other associated equipment such as a control unit, necessary to form a complete heating system.

The low-voltage secondary circuits are not permitted to be grounded and the system is not required to be ground-fault protected. The low-voltage space heating equipment is considered a continuous load and is permitted to be supplied by a branch circuit rated 30 amps or less.

The power unit for a low-voltage system must be an isolating power supply with a rated output not exceeding 25 amps, 30-volts AC (42.4-volts peak) or 60-volts DC. The power supply, low voltage heaters, and other associated equipment must be identified for use in dry locations.

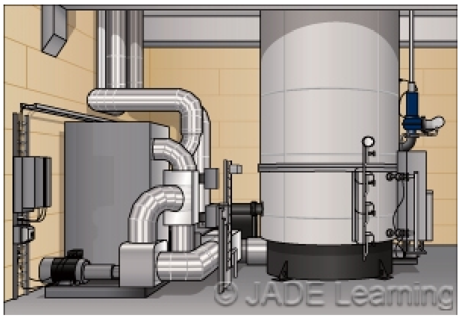
Listed low-voltage space-heating equipment may be supplied directly from an alternate power source, such as solar photovoltaic (PV) or wind generator systems, but the output of the source is still limited to 25 amps, 30-volts AC (42.4-volts peak) or 60-volts DC. The alternate power source and power conversion equipment must also be listed and installed in accordance with NEC requirements.

Question 14: Which of the following statements about the power supply unit for low-voltage fixed electric space-heating equipment is true?

A: The rated output of the power unit shall not exceed 30 amps, 60-volts DC
B: The power unit shall be identified for use in a dry location.
C: The power unit shall be GFCI protected.
D: The power unit shall be supplied by a branch circuit rated 20-amps or less.

Question 15: Article 425 Fixed Resistance and Electrode Industrial Process Heating Equipment.

Question ID#: 1164.0



Article 425 covers fixed industrial process heating equipment that uses resistance or electrode heating technology.

The types of equipment covered by Article 425 includes boilers, electrode boilers, duct heaters, strip heaters, immersion heaters, and process air heaters. Other approved fixed electric equipment used for industrial process heating is also covered by Article 425.

Article 425 covers fixed industrial process heating equipment that uses resistance or electrode heating technology. This type of equipment is different than other types of heating equipment, and the requirements of Article 424 for heating and room air conditioning, Article 427 fixed heating for pipelines and vessels, and Article 665 induction and dielectric heating equipment do not apply to Article 425.

Article 425 contains the following Parts:

Part I General

- Branch circuits are considered continuous loads.
- All equipment shall be listed.

Part II Installation

- Working space must comply with 110.26 or 110.34, depending on the voltage to ground.
- Equipment requiring supply conductors rated over 60Â°C shall be clearly marked

Part III Control and Protection of Fixed Industrial Process Heating Equipment

- The disconnecting means shall simultaneously disconnect the heater, motor controllers and supplementary overcurrent protective devices.
- If the equipment is supplied by more than one source the disconnecting means shall be grouped and identified as having multiple disconnecting means.

Part IV Marking of Heating Equipment

- A nameplate is required giving the normal rating in volts and watts or in volts and amperes.
- All heating elements that are replaceable must be legibly marked with the ratings in volts and watts ***or*** in volts and amperes.

Part V Fixed Industrial Process Duct Heaters

- The fan and heater circuit must be interlocked.
- Temperature limiting controls that will de-energize the duct heater circuits must be installed.

Part VI Fixed Industrial Process Resistance-Type Boilers

- In an ASME-rated vessel rated more than 120 amperes, the loads shall be subdivided in loads not exceeding 120 amps.
- Subdivided loads shall have supplementary overcurrent protection.

Part VII Fixed Industrial Process Electrode-Type Boilers

- Branch circuit conductors and overcurrent protection are based on 125% of the total load (motors not included).
- A pressure-sensitive limiting means shall be installed to limit maximum pressure and shall directly or indirectly interrupt all current flow through the electrodes.

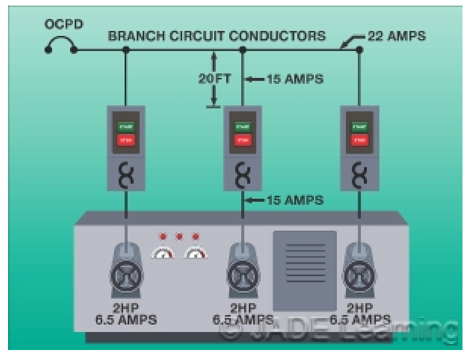
Question 15:   Which of the following types of equipment are covered in Article 425?

A: Fixed electric space-heating equipment.
B: Fixed electric heating equipment for pipelines and vessels.
C: Induction and dielectric heating equipment.
D: Fixed industrial process heating equipment.

Question 16:   430.53(D)(4) Several Motors or Loads on One Branch Circuit. Single Motor Taps.

Question ID#: 1165.0

A new 25 ft. branch circuit tap rule has been added for conductors supplying a single motor in a group installation. A group installation is where one branch circuit supplies two or more motors or a motor(s) and other loads. The single motor (in a group) branch circuit tap rule is now consistent with feeder tap rules found in 430.28.



The rules for tap conductors when several motors are connected to a single branch circuit are similar to the rules for motor feeder taps.

Using the New 25 ft. Tap Rule

The following conditions must be met if the electrician wishes to use tap conductors up to 25' to serve a single motor that is part of a group installation:

- The single motor must be part of a group installation as described in 430.53(A), (B) or (C).
- The tap conductors must terminate at one of the following:

1. A listed manual motor controller additionally marked "Suitable for Tap Conductor Protection in Group Installations," ***OR***

2. A branch-circuit protective device.

- The tap conductors must have an ampacity not less than 1/3 the ampacity of the branch-circuit conductors.
- The tap conductors must be protected from physical damage AND:
- be contained within the controller enclosure ***OR,***
- be installed in a raceway from the point of the tap to the controller ***OR,***
- have an ampacity not less than the branch circuit conductors.

- The total length of the tap conductors from the point of the tap to the controller cannot exceed 25 ft.
- The ampacity of the conductors from the controller to the motor must not be less than required by 430.22.

In no case can the ampacity of the tap conductors be less than the ampacity required by 430.22 to supply the motor. In general, 430.22 requires the ampacity of conductors supplying a single continuous duty AC motor to be not less than 125% of the motor full load current. Motor full load current values are found in Table 430.247, Table

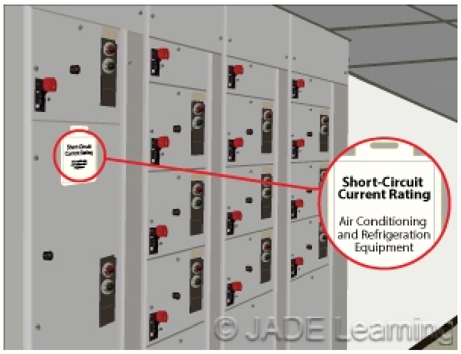
430.248, Table 430.249 and Table 430.250.

Question 16: A motor is part of a group: The tap conductors from the branch circuit terminate at an overcurrent device protecting the motor, and the taps are 20 ft. in length and inside of a protective raceway. The taps supply a motor with a full load current of 10 amps. The minimum ampacity of the conductors supplying the motor is 12.5 amps per 430.22 (125% of the motor FLC). The branch circuit conductors are rated 60 amps. What is the minimum ampacity of the tap conductors?

A: 20 amps.
B: 24 amps.
C: 30 amps.
D: 60 amps.

Question 17: 430.99 Motor Control Centers. Available Fault Current.

Question ID#: 1166.0



The available short-circuit current must not be greater than the short-circuit current rating of the equipment.

The available short-circuit current at a motor control center must now be documented and made available ***"to those authorized to inspect the installation."***

Section 430.98 of the NEC requires a motor control center to be marked with the short-circuit current rating of the equipment. A short-circuit current rating is the maximum fault current that electrical equipment can carry without extensive damage to the equipment. Short-circuit current ratings and interrupting ratings are often confused, but they are not the same thing. A fuse or circuit breaker has an interrupting rating, which is the highest current that it can safely interrupt. Short-circuit current ratings apply to equipment which is not intended to interrupt current.

A short-circuit rating equal to or greater than the available fault current ensures that the motor control center can carry the rated short-circuit current until a fuse or circuit breaker opens and interrupts the current flow to the equipment.

In order to confirm that the motor control center is installed within its short-circuit current rating, an inspector must know what the available fault current is at the motor control center. The available fault-current at the motor control center is dependent on many factors. Transformers, supply conductors, and overcurrent devices ahead of the motor control center must all be considered when calculating the available fault-current. A short-circuit current calculation is typically performed by an electrical engineer during the design of the electrical system, but until now the available short-circuit current at motor control centers was not required to be documented and made available to the electrical inspector in the field.

The short-circuit current calculation must be updated anytime changes are made to the electrical system that affect the available fault current at the motor control center. For example, replacing a transformer with a more energy efficient lower impedance transformer may significantly increase the available fault current at the motor control center. This is why it is important that the documentation include the date the short-circuit current calculation was performed.

By comparing the short-circuit rating marked on the motor control center with the available short-circuit current, the inspector can confirm that the available fault current does not exceed the rating of the motor control center.

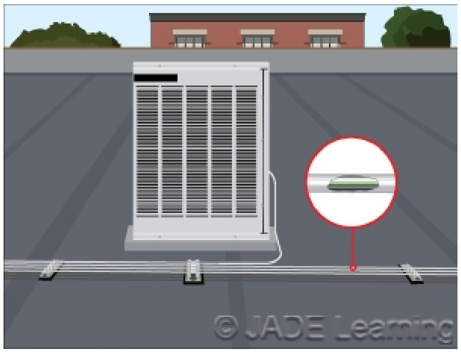
Question 17: A motor control center with a marked short-circuit current rating of 42kA (42,000 amps) was installed in 1990 and the system was modified in 2001. If the 1990 motor control center is replaced with a new 65kA rated motor control center, which of the following statements is true?

A: A short-circuit current calculation must be performed and made available to the authorized inspector.
B: The new motor control center must be field marked with a 42kA short-circuit current rating.

C: A short-circuit current calculation is not required.
D: The new motor control center must be labeled, "Available Fault Current Unknown."

Question 18: 440.9 Air-Conditioning and Refrigerating Equipment. Grounding and Bonding.

Question ID#: 1167.0



A wire type equipment grounding conductor must be installed in metallic raceways that are installed outdoors on a roof and use non-threaded fittings and that supply multimotor or combination load equipment.

A wire type equipment grounding conductor is now required to be installed in metallic raceways installed outdoors on a roof to supply multimotor or combination-load air-conditioning and refrigerating equipment. The wire type equipment grounding conductor is only required for metallic raceways, such as Electrical Metallic Tubing (EMT), that are installed using non-threaded fittings. Non-threaded fittings are also available for rigid metal conduit. A wire type equipment grounding conductor is required to be installed in rigid metal conduit if non-threaded fittings are used. The wire type equipment grounding conductor is required in the outdoor portions of the raceway system only.

EMT is often used to supply air-conditioning or refrigerating equipment on rooftops. Although EMT is recognized as an equipment grounding conductor by Article 250, EMT on rooftops is often damaged or moved during routine roof maintenance and may separate at couplings or other fittings. The damage should be reported and repaired, but this is often not done. If the EMT serves as the only equipment grounding conductor, the equipment ground path is lost if the conduit separates at a coupling. The same problem can occur with other metallic raceways if non-threaded fittings are used. The loss of the equipment ground path creates an unsafe situation and may prevent fuses or circuit breakers from operating to clear faults in the air-conditioning or refrigerating equipment.

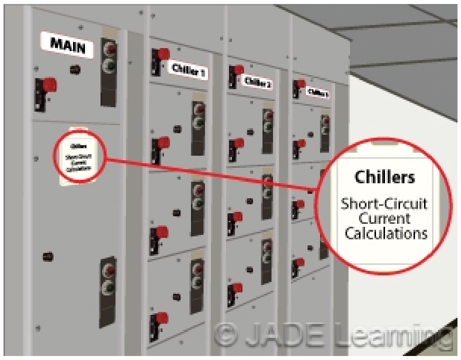
Adding a wire type equipment grounding conductor in metallic raceways using non-threaded fittings is intended to ensure that the equipment ground path remains intact even if the raceway system is not properly maintained. The equipment grounding conductor must be sized in accordance with Table 250.122, but is not required to be larger than the circuit conductors supplying the equipment.

Question 18: Branch circuit conductors supplying rooftop air-conditioning equipment are installed in EMT outdoors on the roof. Which of the following statements about a wire type equipment grounding conductor is true?

A: A wire type equipment grounding conductor is not required to be installed in the EMT.
B: A wire type equipment grounding conductor is not required if set screw fittings are used.
C: A wire type equipment grounding conductor is not required if EMT compression type fittings are used.
D: A wire type equipment grounding conductor is only required in the outdoor portions of the EMT raceway.

Question 19: 440.10 Air-Conditioning and Refrigerating Equipment. Short-Circuit Current Rating.

Question ID#: 1168.0



For air-conditioning and refrigeration equipment the available short-circuit current must be calculated and made available to the inspector at the time the installation is inspected.

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Motor controllers of multimotor and combination-load air-conditioning and refrigerating equipment must not be installed where the available short-circuit current exceeds the short-circuit current rating marked on the equipment nameplate. The available short-circuit current must be calculated and made available to the inspector at the time the installation is inspected.***Â***

Motor controllers and industrial control panels are evaluated by testing agencies to determine the short-circuit current that the equipment can carry without sustaining unacceptable damage to the equipment. The short-circuit current rating of motor controllers and industrial control panels is required to be marked on the nameplate of multimotor and combination-load equipment air-conditioning and refrigerating equipment (440.4(B)). The short-circuit current rating of the equipment must not be less than the calculated available short-circuit current at the equipment. The calculated short-circuit current at the equipment must now be ***â€œdocumented and made available to those authorized to inspect the installation.â€•*** (440.10). The documentation must include the date the calculation was performed.

Although short-circuit current calculations are typically performed by a professional engineer at the time an electrical system is designed, this information has not always been available to the inspector in the field. The available short-circuit current may also change as modifications are made to the electrical system over time. Changing transformers, motors, generators or other equipment may significantly increase the available short-circuit current. The short-circuit current calculation must be updated if modifications are made to the electrical system in order to keep the calculation accurate. This is why the date the short-circuit current calculation was performed is important for the inspector to know.

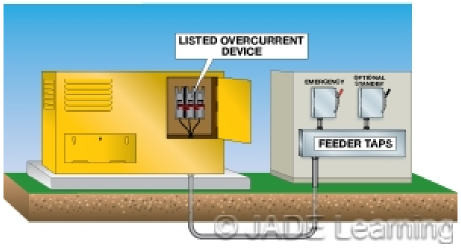
By comparing the short-circuit current rating marked on the air-conditioning or refrigerating equipment nameplate with the calculated available short-circuit current, the inspector can verify that the available short-circuit current does not exceed the rating of the equipment.Â

Question 19: The calculated available short-circuit current at multimotor air-conditioning equipment is 45,000 amps. Which of the following short-circuit ratings on the equipment nameplate is the minimum short-circuit current rating required?

A: 42,000 amps.
B: 45,000 amps.
C: 65,000 amps.
D: 10,000 amps.

Question 20: 445.13(B) Generators. Ampacity of Conductors. Overcurrent Protection Provided.

Question ID#: 1169.0



If a stationary generator rated above 15 kW is equipped with a listed overcurrent device, taps to the generator feeder can be made on the load side of listed overcurrent device.

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This change adds a new Subsection(B) that is intended to clarify when taps can be made on the load side of generators equipped with approved overcurrent protective devices. According to this Section, the overcurrent protection can consist of a current transformer and overcurrent relay, or a listed fuse or circuit breaker, or other listed overcurrent protective device.

With this change, it is clear that the conductors on the load side of a listed overcurrent protective device will be treated as feeders and will be permitted to be tapped under the "tap rules" of 240.21(B). This has been a common practice, but Article 445 was not clear on whether it was permitted or not.

However, this permission for using tap conductors only applies to larger generators where field-wiring connections (termination points) are accessible on the load side of a listed overcurrent protective device. Smaller portable generators are typically connected by cord and plug connection, so the use of tapped conductors is not permitted for any portable generator rated 15 kW or less where terminals for field wiring connections are not accessible.

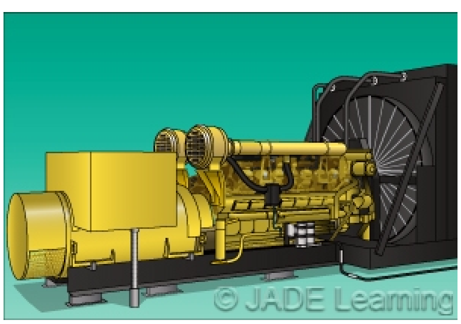
The previous rule that is now 445.13(A) only addressed the size or ampacity of the conductors from the generator to the first distribution device or devices that contain an overcurrent device. That rule was changed to clarify that the conductors in question are only those from the output terminals of the generator, not to all conductors that are internal to the generator.

Question 20: When are taps NOT permitted on the load side terminals of a generator equipped with a listed overcurrent device?

A: When the generator is over 15kW and terminals for making field wiring connections are accessible.
B: When generators are rated 15 kW or less and terminals for making field wiring connections are not accessible.
C: When protection from the listed overcurrent device is replaced with protection from a current transformer and overcurrent relay.
D: When the generator has accessible terminals for making field wiring connections and is over 15kW.

Question 21: 445.18(A), (B), (C) Disconnecting Means and Shutdown of Prime Mover. Disconnecting Means, Shutdown of Prime Mover, Generators Installed in Parallel.

Question ID#: 1170.0



A disconnecting means must be provided for the generator and the prime mover. The disconnecting means must disable start circuits so the generator cannot restart without a mechanical reset.

This section was revised to clarify and expand on three issues: (A) the requirements for generator disconnecting means, (B) the requirements for the shutdown of the generator's prime mover, and (C) the requirements for isolating generators from the paralleling equipment when generators are operated in parallel.

Section 445.18(A) simplifies the requirement for a disconnecting means by simply stating that a disconnecting means must be provided to isolate all associated ungrounded conductors. More than one disconnect may be used. The disconnecting devices must be capable of being locked in the open position. This requirement does not apply to cord-and-plug-connected generators because the cord-and-plug connection serves as a disconnecting means. "Associated ungrounded conductors" is intended to mean that each disconnect is only required to open the conductors supplied through that disconnect and that it is not necessary to have all disconnects operate together or be interlocked. It is not intended to refer to conductors not supplied primarily by the generator, such as battery chargers or crankcase heaters.

Section 445.18(B) is a new requirement for a provision to shut down a prime mover such as a diesel engine. The provision must disable start circuits so the generator cannot restart without a ***mechanical reset***. If the provisions for shutting down the generator can be locked in the open position, they can also serve as the disconnecting means. For generators rated over 15kW, an additional shutdown means that provides the same functions must be located outside the generator equipment room or enclosure.

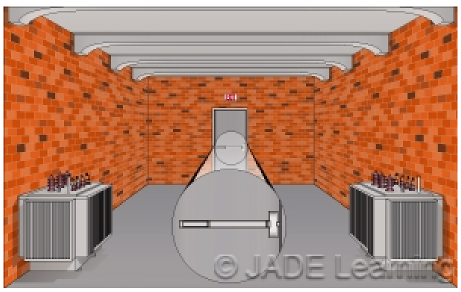
Section 445.18(C) clarifies that where multiple generators operate in parallel it is not necessary to provide a disconnecting means at each generator and at the paralleling equipment. The disconnects must isolate the generator output terminals from the paralleling equipment and the disconnects may be located at the paralleling equipment, or at the generators.

Question 21:   Disconnecting means for each generator operating in parallel is/are required at which of the following locations?

A: Disconnect must be located at each generator.Â Â
B: Disconnect is required at each generator and at the paralleling equipment.Â Â
C: Disconnect must be located at the paralleling equipment location only.Â Â
D: Disconnect must be located where the disconnect will isolate the generator from the paralleling equipment.Â Â

Question 22:   450.43(C) Transformer Vaults. Doorways. Locks.

Question ID#: 1171.0



In transformer vaults personnel doors are required to open in the direction of egress and be equipped with listed panic hardware.

Personnel doors providing access to transformer vaults are required to "***open in the direction of egress and be equipped with listed panic hardware."*** The language in 450.43(C) has been changed to be consistent with the general requirements for access to electrical equipment in 110.26(C)(3).

Transformer vault doorways are required to have a 3-hour fire resistance rating. All doors to transformer vaults are required to be kept locked with access restricted to qualified persons only. If it is necessary to enter a transformer vault while conductors or equipment is energized, it is important that the qualified person(s) be able to escape the room quickly in the event of an accident or equipment malfunction. Personnel doors are required to open in the direction of egress and be equipped with listed panic hardware so that a person leaving the room will have to exert only minimal effort in order to escape the room.

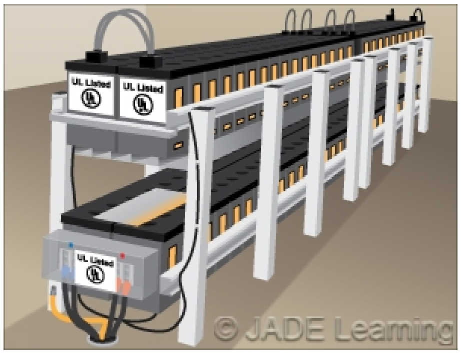
Listed panic hardware allows a door to be opened from the egress side by a simple push. This is especially important in the event that a person has suffered burns to their hands and are unable to operate a door knob. The NFPA Life Safety Code (NFPA 101) requires panic hardware and fire exit hardware to unlatch when subjected to no more than 15 lbs. of force. Listed panic hardware will meet this requirement.

Question 22:   Which of the following statements about personnel doors in transformer vaults is true?

A: Personnel doors must open in the direction of egress.
B: Personnel doors must have a 4-hour fire resistance rating.
C: Personnel doors must be kept unlocked during normal business hours.
D: Listed panic hardware is not required by the NEC.

Question 23: 480.3 Storage Batteries. Equipment.

Question ID#: 1172.0



Storage batteries must be listed.

A new section requires all storage batteries, except lead-acid batteries, and all battery management equipment to be listed. This new requirement is intended to address the hazards of newer battery technologies and batteries using different chemical reactions.

The primary purpose of this requirement for third party evaluation is to make the necessary information and instructions that are part of listing and labeling available to those who design, install, maintain, and inspect battery installations. This will help ensure safe battery installations.

Lead-acid batteries are excluded from the requirement because they are thought to be adequately covered by the existing requirements of Article 480 that are based on many decades of experience. However, new types of batteries have presented some new and somewhat different hazards. Some of the newer batteries have much higher current densities than older types, that is, they provide for a lot more power in a smaller and lighter package. Lithium ion batteries are one example.

Widely publicized explosions and fires have been connected to some of these newer battery technologies. These incidents have been found to be related to both the battery technologies as well as the battery management systems that control electrical and thermal characteristics of the batteries. Therefore, listing is required for both the batteries and the equipment that manages the batteries.

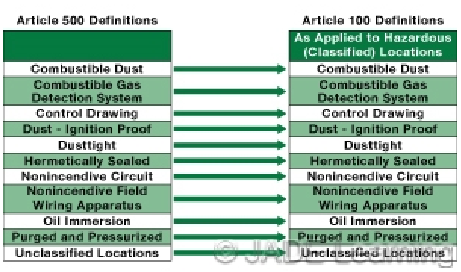
Question 23: Which of the following are NOT required to be listed?

A: Battery management systems.
B: Lithium Ion batteries.
C: Lead-acid batteries.
D: Battery chargers.

Chapter 5

Question 24: 500.2 Special Occupancies. Definitions â€“ Relocated.

Question ID#: 1173.0



A number of definitions were moved from Article 500 to Article 100.

Chapter 5 of the NEC deals with many different types of Special Occupancies including, but not limited to, hazardous (classified) locations, agricultural buildings, health care facilities, aircraft hangers, motor fuel dispensing facilities, commercial garages, bulk storage plants, spray applications, and similar installations. Hazardous (classified) locations may be found in almost any occupancy.

Article 500 through 504 cover the general requirements for wiring in hazardous (classified) locations. Hazardous (classified) locations are sometimes simply called "classified locations". Article 500 explains the various hazard classifications in Class I, Class II, and Class III, hazardous (classified) locations. Section 500.2 in the 2014 NEC included definitions for terms used in Articles 501, 502, 503, and 506 of the code.

Section 500.2 was deleted and definitions for the following terms were moved to Article 100: Combustible Dust, Combustible Gas Detection System, Control Drawing, Dust-Ignition proof, Dusttight, Hermetically Sealed, Nonincendive Circuit, Nonincendive Component, Nonincendive Equipment, Nonincendive Field Wiring, Nonincendive Field Wiring Apparatus, Oil Immersion, Purged and Pressurized, and Unclassified Locations.

Generally, terms used in two or more articles are defined in Article 100. All of the relocated terms are used in more than one article. The use of these terms in more than one article was not a new issue. However, since Article 100 is generally overseen by Code-Making Panel 1, and the articles covering Hazardous(Classified) Locations are the responsibility of Code-making Panel 14, concerns were expressed that the technical experts familiar with hazardous (classified) locations would lose control of those definitions. As a result, a revision was also made in Article 100 to indicate in each definition which Code-Making Panel (CMP) is responsible for the definition.

All of the definitions relocated to Article 100 from 500.2 now include the notation (CMP-14) following the definition. Other definitions use the same type of notation. In addition, after each defined term, the words "as applied to Hazardous (Classified) Locations" now appear in brackets. Also, some of the defined terms related to intrinsically safe systems were relocated from Section 504.2 and include the same notations in Article 100. However, Section 504.2 was not deleted.

Definitions specific to only one article can be found with that article. For example, definitions for intrinsically safe apparatus, intrinsically safe circuit, and intrinsically safe system are all located in Section 504.2. These terms have a specific meaning within the context of Article 504, Intrinsically Safe Systems.

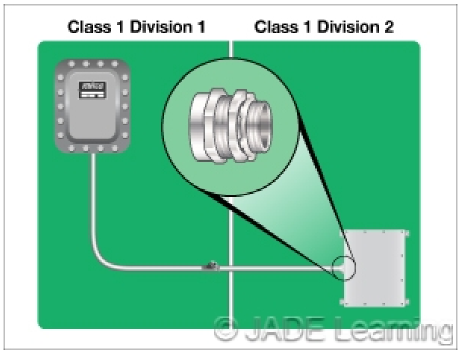
Moving the definitions from 500.2 to Article 100 was required because the terms were used in more than one article. The NEC is written to follow the writing style and rules outlined in the NEC Style Manual. The NEC Style Manual is a separate document that outlines how the written structure of the NEC is to be laid out. Conformity with the NEC Style Manual brings a consistency throughout the entire document that makes it more "reader friendly". There is an informational note after NEC Section 90.5(C) that gives some commentary on the NEC Style Manual, including where a copy of it can be obtained.

Question 24: What happened to the definitions that were removed from Section 500.2?

A: They were deleted from the NEC.
B: They were moved to the sections where they were used.
C: They were relocated to Informational Notes.
D: They were relocated to Article 100.

Question 25: 501.10(B)(1) Wiring Methods. Class I, Division 2. General.

Question ID#: 1174.0



Threadless fittings for rigid metal conduit and intermediate metal conduit can be used in Class I, Division 2 locations.

Article 501 covers the requirements for electrical and electronic equipment and wiring in Class I, Division 1 and Division 2 locations where fire or explosion hazards exist due to flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors. The rules for wiring methods in a Class I, Division 2 location are less stringent than they are for a Class I, Division 1 area. In a Division 1 area it would be considered normal to have concentrations of explosive gases or vapors present during normal operation. A Division 2 area would not normally have concentrations of explosive gases or vapors in the air, but explosive gases or vapors are present within normally closed containers or systems.

Any of the wiring methods allowed in a Class I, Division 1 location may also be used in a Class I, Division 2 location. The wiring methods allowed in Class I, Division 1 locations are: Threaded Rigid Metal Conduit, Threaded Intermediate Conduit, Type MI Cable (Mineral Insulated), Type MC-HL Cable (Metal Clad- Hazardous Locations), and Type ITC-HL Cable (Instrument Tray Cable - Hazardous Locations). Several different types of Optical Fiber Cables are permitted where installed in one of the raceways listed in 501.10(A). Type PVC, RTRC and HDPE nonmetallic conduits are permitted under not less than 24 inches of cover and encased in not less than 2 inches of concrete. Threaded rigid metal conduit and threaded steel intermediate metal conduit must be used for the last 24 inches of the underground run.

In a Class I Division 2 location, Rigid Metal Conduit with threadless fittings, Intermediate Metal Conduit with threadless fittings, Enclosed Gasketed Busways and Wireways, Type MC Cable, Type MV Cable, Type TC Cable and Type TC-ER Cable (Tray Cable - Exposed Run) are also permitted wiring methods. Optical fiber cables are permitted to be installed in cable trays, as well as in the other raceways listed in 501.10(B).

The 2017 change is that threadless fittings for rigid metal conduit (RMC) and intermediate metal conduit (IMC) are now permitted in Class I, Division 2 locations. The 2014 NEC permitted threaded rigid metal conduit or threaded steel intermediate metal conduit in Class I, Division 2 locations, but not threadless fittings.

Threadless fittings for rigid metal conduit (RMC) and intermediate metal conduit (IMC) will maintain the equipment grounding path when installed according to the listing for the fittings. RMC and IMC conduit can be used as the equipment grounding conductor in a Class I, Division 2 location, just as they can be in non-hazardous locations. Threadless fittings are not permitted for rigid metal conduit or intermediate metal conduit in a Class I Division 1 location.

In hazardous locations, it is critical that the electrical system does not create sparks. Where properly installed threadless fittings for RMC and IMC provide an acceptable equipment grounding path in a Class I Division 2 location. In a Class I Division 1 area, threaded fittings are required because of the increased hazard presented by flammable gases or vapors in the air.

Where flexible connections are required listed flexible metal fittings, flexible metal conduit with listed fittings and interlocked armor Type MC cable with listed fittings are permitted wiring methods. Type AC cable is not permitted for power wiring in a Class I Division 2 area.

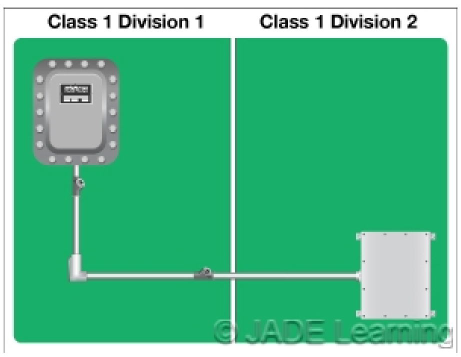
Cablebus was also added to the list of allowed wiring methods in Class I, Division 2 areas. Cablebus is similar in many respects to cable tray installations, which were already allowed in Class I Division 2 hazardous (classified) locations.

Question 25: Which of the following statements is true?

A: Threadless fittings for RMC and IMC are not permitted in Class I, Division 2 locations.
B: Threadless fittings for RMC and IMC are permitted in Class I, Division 2 locations.
C: Threadless fittings for RMC and IMC are permitted in Class I, Division 2 locations if the conduit size is greater than 1 inch.
D: Threadless fittings for RMC and IMC are permitted in Class I, Division 2 locations if the conduit size is greater than 1 1/2 inch.

Question 26: 501.15(A)(1) Sealing and Drainage. Conduit Seals, Class I, Division 1. Entering Enclosures.

Question ID#: 1175.0



Conduit bodies cannot be used between the explosionproof enclosure and the conduit seal.

Conduit bodies, such as an LB or C type conduit body, are no longer permitted between a seal fitting and an explosionproof enclosure.

In a Class I, Division 1 area an enclosure containing switches, circuit breakers, or other apparatus that may produce arcs, sparks or temperatures exceeding 80% of the autoignition temperature of the flammable gases or liquid-produced vapors present in the Class I area must be identified for use in a Class I, Division 1 location.

Enclosures identified for use in Class I, Division 1 locations include both purged and pressurized enclosures intended to prevent the accumulation of flammable gases or vapors within the enclosure and explosionproof enclosures designed to withstand a small explosion within the enclosure without allowing hot gases to escape the enclosure and ignite gases or vapors within the surrounding Class I, Division 1 area.

Explosionproof seals must be installed in conduits entering an explosionproof enclosure. The seal will help contain any explosion within the enclosure and also prevent ignitable quantities of flammable gases or vapors traveling through the conduit to another enclosure or to an area with a less hazardous classification. Conduit seals must be located within 18 in. of explosionproof enclosures or within the distance marked by the manufacturer on a listed enclosure.

Locating the seal close to the enclosure reduces the volume of the air/gas mixture within the enclosure and raceway so that the enclosure can withstand any likely internal explosion. Only one conduit seal is needed in a nipple between two explosionproof enclosures as long as the nipple is not over 36 inches long so that the seal will be no more than 18 inches from each enclosure.

If a conduit body is installed between the seal fitting and an explosion proof enclosure, the volume of air/gas mixture within a conduit body may be enough to exceed the capacity of the explosionproof enclosure to withstand an internal explosion. Failure of the explosionproof enclosure could ignite flammable gases or liquid produced vapors present in the Class I Division 1 area. Failure of the seal could open a passage for gases or vapors to accumulate within and travel through the conduit system to other enclosures or to unclassified locations.

Only explosionproof unions, couplings, reducers, elbows, and capped elbows, that are not larger than the trade size of the conduit are permitted between the sealing fitting and an explosionproof enclosure.

The exceptions to the requirements for conduit seals have also been revised. Conduit seals are not required for identified enclosures containing circuit breakers, fuses, switches, or similar apparatus if the enclosure is marked as "factory sealed," "seal not required," or an equivalent marking.

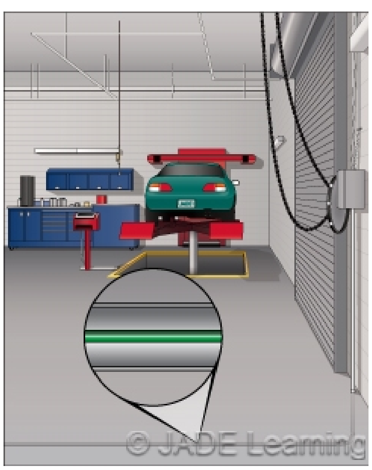
A seal fitting is also needed in a conduit run that leaves the Class I Division 1 location. The seal must be located within 10 ft. of the boundary and no couplings are allowed in the conduit between the seal and the boundary. Seals are also required in 2 inch or larger conduits that enter explosionproof boxes in Class I Division 1 locations if the box has splices, terminals or taps.

Question 26: Why are conduit bodies no longer permitted between the conduit seal and an explosionproof enclosure in a hazardous location?

A: They do not have a seal.
B: They are not readily available.
C: They increase the air volume in a raceway system.
D: They decrease the volume of air in a raceway system.

Question 27: 511.8 Commercial Garages, Repair and Storage. Underground Wiring.

Question ID#: 1176.0



If PVC is used for underground wiring in a commercial garage a wire-type equipment grounding conductor is required to be installed.

A new section has been added to Article 511 Commercial Garages. Underground wiring in a commercial garage is required to be installed in threaded rigid metal conduit or threaded intermediate metal conduit. This is consistent with wiring methods located within a hazardous (classified) location. A Class 1 Division 2 space extends up 18 inches above the floor in repair garages where vehicles that use heavier than air fuels, such as gasoline, are repaired. Where threaded rigid metal conduits or threaded intermediate metal conduits pass through a classified (hazardous) area seal fittings may be required.

An exception permits Type PVC conduit, Type RTRC conduit, and Type HDPE conduit to be used where buried under not less than 2 ft. of cover. Where emerging from the earth, threaded rigid metal conduit or threaded intermediate metal conduit must be used from a point 2 ft. below cover to the point of emergence or the point of connection to an aboveground raceway system. The use of threaded rigid metal conduit or threaded intermediate metal conduit for the portion of the conduit run that emerges from grade will provide physical protection and permit the installation of conduit seals if conduit enters or passes through a hazardous (classified) area.

Where Type PVC conduit, Type RTRC conduit, or Type HDPE conduit is used, an equipment grounding conductor sized in accordance with Table 250.122 must be installed.

There is no requirement in Article 511 that underground runs of Type PVC, Type RTRC, or Type HDPE nonmetallic conduits be encased in concrete or installed below 2 inches of concrete. Not all commercial garages have concrete floors, some garages for heavy equipment such as logging equipment have earth floors. Care should be taken during installation to ensure that 2 ft. of cover is maintained to prevent damage to the nonmetallic conduit runs caused by the weight or movement of heavy equipment.

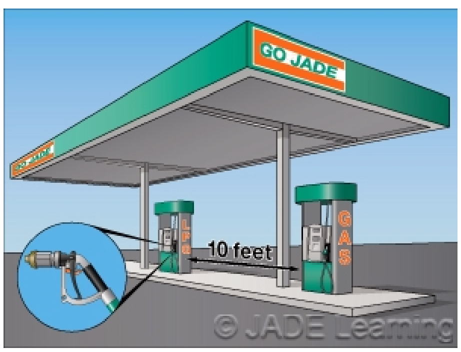
Prior to the 2017 NEC, there was no specific permission to use Type PVC, Type RTRC, or Type HDPE conduit for underground wiring at a commercial garage. Some AHJ's applied the rules in 514.8 for these installations, but Article 514 addresses Motor Fuel Dispensing Facilities which are not present at all commercial garages. With this new section, there should be no confusion on the rules for underground wiring at a commercial garage.

Question 27: In a commercial garage, which of the following types of conduit can be installed underground?

A: Flexible Metallic Tubing.
B: Liquidtight Flexible Nonmetallic Conduit.
C: Intermediate Metallic Conduit.
D: Electrical Metallic Tubing.

Question 28: 514.3(B)(2) Motor Fuel Dispensing Facilities. Classified Locations. Compressed Natural Gas, Liquefied Natural Gas, and Liquefied Petroleum Gas Areas.

Question ID#: 1177.0



The minimum required distance between LPG dispensers and Class I liquid dispensers is now 10 feet.

Article 514 covers motor fuel dispensing facilities located both inside and outside of buildings and fleet vehicle motor fuel dispensing facilities. Section 514.3 covers the classification of hazardous areas around dispensing devices, pumps, tanks, and vapor processing systems associated with these fuel dispensing facilities. Section 514.3(B)(2) has been updated to clarify the requirements for compressed natural gas (CNG), liquified natural gas (LNG), and liquified petroleum gas (LP-Gas) fuel dispensing facilities. These types of fuel dispensing facilities are becoming more common. The limits of the hazardous (classified) areas around CNG, LNG, and LP-Gas fuel dispensing devices are shown in Tables 514.3(B)(2).

Two new conditions apply where dispensing devices for both Class I liquids (such as gasoline) and LP-Gas are located at the same facility.

The minimum distance between a dispensing device for LP-Gas and a dispensing device for Class I liquids has been increased from 5 ft. to 10 ft. The distance can be reduced to 5 ft. where the LP-Gas dispensing device meets the following conditions:

(1) The LP-Gas deliver nozzle and filler valve release no more than 4 cm3 (0.1 oz.) of liquid upon disconnection. (2) The fixed maximum liquid level gauge remains closed during the entire refueling process.

LP-Gas, sometimes referred to as propane is heavier than air and may accumulate in open spaces beneath dispensers. The entire space within an LP-Gas dispenser and any pits or trenches within 20 ft. horizontally of an LP-dispenser are classified as Class I Division 1 locations in Table 514.3(B)(2). The area 18 in. above ground and within 20 ft. horizontally of any edge of an LP-Gas dispenser is classified as a Class I Division 2 location.

Natural gas is a lighter than air fuel. Where compressed natural gas (CNG) or liquified natural gas (LNG) dispensers are installed beneath a canopy, the canopy must either be designed to prevent the entrapment of ignitable quantities of gas vapors or all electrical equipment beneath the canopy must be suitable for use in a Class I Division 2 hazardous (classified location).

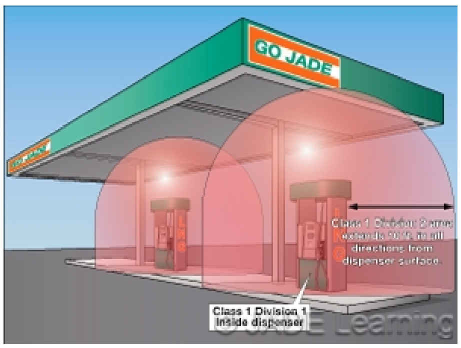
The variety of different motor vehicle fuels available continues to increase. The different fuels have different properties. Some are lighter than air, such as compressed hydrogen and will disperse quickly if released in the air. The vapors of other fuels such as gasoline or liquified petroleum are heavier than air and will accumulate in pits or enclosures creating an explosion hazard. The classification of areas around fuel dispensers is largely based on the requirements found in NFPA-30A, Code for Motor Fuel Dispensing Facilities and Repair Garages.

Question 28: How far from gasoline dispensers must a dispensing device for liquefied petroleum gas be located in a typical application?

A: 20 feet.
B: 12 inches.
C: 10 feet.
D: 50 feet.

Question 29: Table 514.3(B)(2) Electrical Equipment Classified Areas for Dispensing Devices.

Question ID#: 1178.0



The area inside a LNG dispenser is a Class I, Division 1 location. The area extending 10 feet in all directions from the LNG dispenser is a Class I, Division 2 location.

The hazardous (classified) areas around dispensing devices for compressed natural gas (CNG), liquified natural gas (LNG), and liquified petroleum gas (LP-Gas) are found in Table 514.3(B)(2). The entire space within a dispenser for any of these fuel types is classified as a Class I, Division 1 location.

In the 2014 NEC a Class I, Division 1 area extended out 5 ft. in all directions from the exterior surface of a liquified natural gas (LNG) dispenser. The Class I Division 1 hazardous (classified) designation for the area extending out from the exterior of the LNG dispenser enclosure has been eliminated in the 2017 NEC. The area extending out 10 ft. in all directions from the exterior surface of a liquified natural gas (LNG) dispenser is now classified as a Class I, Division 2 location.

Natural gas is a lighter than air fuel and vapors will quickly disperse into the air. Improvements in fuel dispensing devices also reduce the amount of gas that may be released. Ignitable concentrations of flammable gases or liquid-produced vapors are normally not present in a Class I, Division 2 area unless there is an accidental rupture or equipment malfunction. The entire space within the enclosure of a liquified natural gas dispenser is still a Class I Division 1 location.

The entire space within a liquified petroleum gas (LP-Gas) dispenser is also a Class I Division 1 area, but for an LP-Gas dispenser the Class I Division 1 area extends out 18 inches from the exterior surface of the dispenser to a height of 4 ft. above the base of the dispenser. Any pit or open space beneath the dispenser or within 20 ft. horizontally of any edge of the LP-Gas dispenser is also a Class I Division 1 area. From ground level to a height of 18 in. above ground and extending out 20 ft. horizontally from the edge of an LP-Gas dispenser is a Class I Division 2 area.

The hazardous (classified) areas around a compressed natural gas (CNG) dispenser have not been changed. The space within the CNG dispenser enclosure is a Class I Division 1 area. The area extending out 5 ft. in all directions from the dispenser enclosure is a Class I Division 2 area.

The changes bring the requirements in the NEC in line with requirements in other NFPA standards including NFPA 30A-2015, ***Code for Motor Fuel Dispensing Facilities and Repair Garages***

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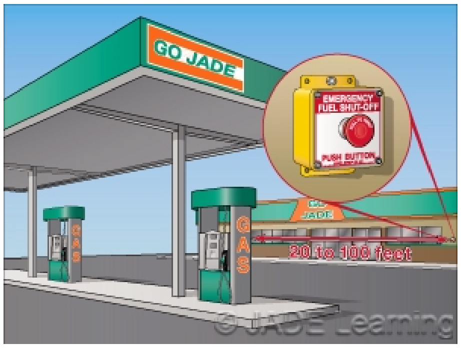
Question 29: A light pole is to be installed 8 ft. from a LNG dispenser. What is the area classification at the base of the pole?

A: Class 1 Division 1.
B: Area is unclassified.
C: Class 1 Division 2.
D: Class 1 Division 3.

Question 30: 514.11 Motor Fuel Dispensing Facilities. Circuit Disconnects.

Question ID#: 1179.0



Emergency disconnects for motor fuel dispensing equipment must be located not less than 20 feet and not more than 100 feet away from the pumps. All power to the dispensing devices must be disconnected.

The title of section 514.11(A) has been changed from ***General*** to ***Emergency Electrical Disconnects***. Emergency disconnects for all motor fuel dispensing facilities are required to be installed not less than 20 ft. and no more than 100 ft. from the fuel dispensing devices they serve. At unattended self-service motor fuel dispensing facilities, an additional disconnecting device is required for each group of dispensers on an individual island.

Section 514.11(A) has been revised to make it clear that the emergency electrical disconnect must disconnect power to all dispensing devices, the remote pumps serving the dispensing devices, all associated power, control and signal circuits, and also disconnect power to any other electrical equipment within the hazardous (classified) locations surrounding the fuel dispensing devices. The only exception from the disconnect requirement is for intrinsically safe electrical equipment. Intrinsically safe circuits are considered incapable of starting a fire.

Where more than one emergency electrical disconnect is installed, all such devices must be interconnected so that all the specified electrical equipment at the facility can be disconnected from any emergency electrical disconnect location.

Once an emergency electrical disconnect is operated, the electrical equipment must remain shut down until the emergency electrical disconnect system is manually reset. The manner of resetting the emergency disconnect must be approved by the authority having jurisdiction.

At an attended self-service fuel dispensing facility, the emergency electrical disconnect must be readily accessible to the attendant. At an unattended self-service fuel facility, the emergency electrical disconnect(s) must be readily accessible to the patrons. Emergency disconnects at both attended and unattended self-service facilities must be not less than 20 ft. or more than 100 ft. from the dispensing devices served. For an unattended facility, an additional readily accessible emergency disconnect shall be provided at each group of dispensing devices on an individual island. Both the disconnect within the 20 ft.-100 ft. distance and the disconnect or disconnecting device for the dispenser island must be readily accessible to the customers who are using the facility.

Providing two disconnect locations at an unattended self-service fueling facility provides a second opportunity for customers to disconnect power to the pumps and dispensers in case of an emergency such as a fire or fuel leak.

The emergency electrical disconnect requirements in 514.11 are extracted from NFPA 30A-2015, Motor Fuel Dispensing Facilities and Repair Garages. The requirements in the 2017 NEC are now the same as found in NFPA 30A-2015.

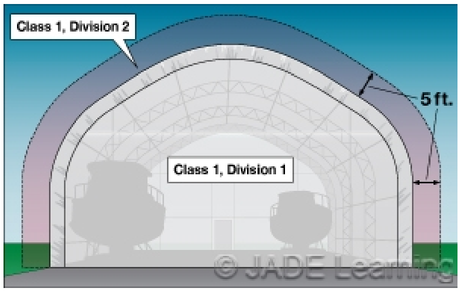
Question 30: What type of reset is required when resetting an emergency disconnect from an emergency shutoff condition?

A: An automatic reset approved by the authority having jurisdiction.
B: A manual reset approved by the authority having jurisdiction.
C: No reset is required.

D: A lighted reset button approved by the authority having jurisdiction.

Question 31: Article 516 Spray Application, Dipping, Coating, and Printing Processes Using Flammable or Combustible Materials.

Question ID#: 1180.0



The area inside a membrane enclosure is a Class I, Division 1 area. The area extending 5 feet outside the membrane area is a Class I, Division 2 location.

Article 516 deals with spray application, dipping, coating, and printing processes using flammable or combustible materials. Article 516 has been completely re-written. Although the code text is substantially reorganized, the hazardous area classifications are basically unchanged.

Technical code requirements extracted from ***NFPA 33: Standard for Spray Application Using Flammable or Combustible Materials*** and ***NFPA 34: Standard for Dipping, Coating, and Printing Processes Using Flammable or Combustible Liquids*** have been updated to the most recent editions. Two new definitions were added in 516.2 to specifically address temporary membrane enclosures and outdoor spray areas.

Temporary membrane enclosures are typically used when the object to be painted is too large for conventional spraying operations. For example, a membrane enclosure may be erected at a marina for painting a large boat.

Membrane Enclosure. A temporary enclosure used for the spraying of workpieces that cannot be moved into a spray booth where open spraying is not practical due to the proximity of other operations, finish quality, or concerns such as the collection of overspray.

Area classification in and around membrane enclosures is now covered in section 516.18. A new Figure 516.18 illustrates a typical example of a membrane enclosure. The inside of the enclosure is a Class 1 Division 1 area. A Class 1 Division 2 area extends 5 ft. out in all directions from the outside edge of the membrane.

The definition of spray area has also been substantially revised to include all areas where dangerous quantities of flammable or combustible vapors, mists, residues, dusts, or deposits are present due to the operation of the spray processes. A new informational note has been added to provide additional information on unenclosed spray areas.

Informational Note: Unenclosed spray areas are locations outside of buildings or are localized operations within a larger room or space......

Spraying operations often occur in outdoor spray areas, but such areas were not defined in the 2014 NEC. A definition has been added.

Outdoor spray area. A spray area that is outside the confines of a building or that has a canopy or roof that does not limit the dissipation of the heat of a fire or dispersion of flammable vapors and does not restrict fire-fighting access or control. For the purpose of this standard, an outdoor spray area can be treated as an unenclosed spray area.

The definition clarifies that objects can be sprayed outdoors under a roof or canopy if the conditions stated in the definition are met. The area classification is the same as for unenclosed spray processes covered by 516.5(D). The outdoor area where spraying occurs is classified as a Class 1 Division 1 area. The area extending out 20 ft. horizontally in all directions from the boundary of the Division 1 spray area is a Class 1 Division 2 area. The Class 1 Division 2 area extends 10 ft. vertically above the highest point of the spray area as well.

Many of the requirements in Article 516 are extracted from NFPA 33-2016, Standard for Spray Application Using Flammable and Combustible Materials. The requirements in the 2017 NEC are now aligned with the requirements in NFPA 33-2016.

Question 31: A membrane structure is erected around a large boat to protect the finish during spray painting. What is the classification of the area 3 ft. above the roof of the membrane structure?

A: Non-hazardous.
B: Class 1 Division 1.
C: Class 2 Division 1.
D: Class 1 Division 2.

Question 32: 517.2 Health Care Facilities. Definitions.

Question ID#: 1181.0

There is a new definition of a medical and dental office.

Article 517 deals with health care facilities and provides electrical construction and installation requirements within health care facilities that provide services to human beings. The provisions of Article 517 do not apply to veterinarian or other animal care facilities.

Definitions for ***Governing Body, Invasive Procedure,*** and ***Medical Office (Dental Office)*** have been added to 517.2. These definitions are taken from NFPA 99-2015, ***Health Care Facilities Code.*** Including specific healthcare related definitions from NFPA 99-2015 makes it easier to understand the electrical installation requirements in Article 517 of the NEC.

Although informational notes in the 2014 NEC referred to the ***governing body of the facility,*** no information was provided as to who or what constituted the governing body. A ***Governing Body*** is now defined in 517.2 as:

The person or persons who have the overall legal responsibility for the operation of a health care facility.

It is the governing body of the facility that is most aware of the type and level of service that will be provided. The governing body of the health care facility will now be the agency that is responsible for classifying the patient care spaces, according to how the space will be used. This information will need to be shared with designers, installers, and inspectors during the construction process.

Also, for the first time in the NEC, a definition is provided for a dental office. Dental care is still included under the general definition of a health care facility, but the range of services provided in dental offices can vary widely.

Medical Office (Dental Office). A building or part thereof in which the following occur: (1) examinations and minor treatments or procedures are performed under the continuous supervision of a medical or dental professional; (2) only sedation or local anesthesia is involved and treatment or procedures do not render the patient incapable of self-preservation under emergency conditions; and (3) overnight stays for patients or 24-hour operation are not provided.

Adding a specific definition for dental office clearly establishes the difference between an office where routine dental care is provided and a medical facility that provides services that may render the patient incapable of self-preservation

The definition of Health Care Facilities has been modified to include mobile enclosures.

Health Care Facilities. Buildings, portions of buildings, or mobile enclosures in which human medical, dental, psychiatric, nursing, obstetrical, or surgical care are provided.

The 2014 NEC did not specifically exclude mobile enclosures, but it was not clear if they were actually considered part of a Health Care Facility. An example of a mobile care facility would be a blood bank. Mobile enclosures offer many of the same procedures as clinics or hospitals and the same potential electrical hazards.

In keeping with NFPA's desire to coordinate terms used in or between different NFPA documents, the definitions of Patient Care Space ***(Basic Care***); Patient Care Space (***General Care***); Patient Care Space (***Critical Care***); and Patient Care Space (***Support Space***) have been expanded to include how these spaces are identified in NFPA 99-***Health Care Facilities Code***. The definitions in the 2017 NEC are now: Patient Care Space (***Basic Care)(Category 3***) ***space***; Patient Care Space (***General Care)(Category 2***) ***space***; Patient Care Space (***Critical Care)(Category1***) ***space***; and Patient Care Space (***Support Space)(Category 4) space.***

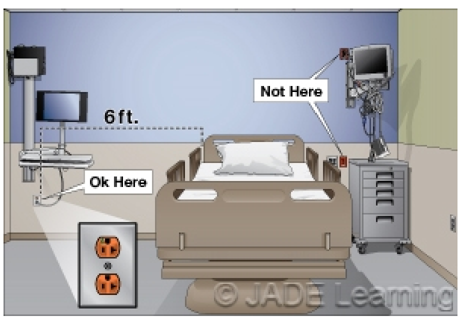
Eventually, the term "Basic Care Space" will be replaced entirely with "Category 3 Space". This will align the terms used in the NEC (NFPA 70) with the Healthcare Facilities Code (NFPA 99).

Question 32: Who is responsible for designating patient care spaces in accordance with the type of patient care that will be provided?

A: The local electrical inspector.
B: The architect or professional engineer of record.
C: The Governing Body.
D: The local building official.

Question 33: 517.16 Health Care Facilities. Use of Isolated Ground Receptacles.

Question ID#: 1182.0



An isolated ground receptacle cannot be installed in the patient care vicinity.

Isolated ground receptacles are used to protect sensitive electronic equipment from electromagnetic interference (called electrical noise or RF noise). Isolated ground receptacles work by allowing only a single insulated equipment grounding conductor (EGC) to connect the green screw on the back of the receptacle to the service equipment (the load center where the branch circuits begin), without ever touching another grounded metal surface in the building. This type of equipment grounding wire is truly isolated from all other metal until it reaches the electrical panel and therefore cannot be part of an "antenna" of metal capable of picking up radio waves throughout the building.

This is a perfectly acceptable wiring method when an isolated ground receptacle is installed for the purpose of protecting electronic equipment. However, the primary concern in a patient care space is the protection of the ***patient.***

An isolated ground type receptacle ***can*** be installed in a patient care space, but it is not permitted in a patient care vicinity. Both patient care spaces and patient care vicinity(s) are defined in 517.2.

Patient Care Space. Any space of a health care facility wherein patients are intended to be examined or treated.

Patient care spaces are classified in accordance with the type of patient care anticipated. Patient care spaces include basic care space, general care space, and critical spaces. A new definition for support space was also added. Support space is an area in which the failure of equipment is ***not*** likely to have a physical impact on patient care.

Generally speaking, a receptacle outlet within a patient care space must be provided with two separate equipment grounding paths, often referred to as- redundant grounding. (1) The first is achieved by installing the circuit conductors in a metal raceway or metal-sheathed cable that runs the length of the circuit. This way if a conductor is nicked and touches the conduit, it will trip the overcurrent device. (2) The second method is achieved by providing an insulated equipment grounding conductor from the receptacle all the way to the electrical panel, with no interruptions or splices. For example, EMT could be used as the first equipment grounding path, and then a separate (green with yellow stripes) insulated equipment grounding conductor could be pulled into the EMT and serve as the second path.

Patient Care Vicinity. A space, within a location (A LOCATION SUCH AS A DOCTOR'S OFFICE, HOSPITAL, ETC.) intended for the examination and treatment of patients. The patient care vicinity extends (6 ft.) beyond the normal location of the patient bed, chair, table, treadmill, or another device that supports the patient during examination and treatment and extends vertically (7 ft. 6 in.) above the floor.

The NEC is telling us to count the ***patient vicinity*** as the area measuring 6 feet to every side of a patient's bed, but to count the ***patient vicinity*** above the bed by starting our measurement at the floor and pulling the tape straight up to a point 7 ft. 6 in. above the floor. This may cause the area called the ***patient vicinity*** to extend only 3 or 4 feet above the surface of the bed mattress. An isolated ground receptacle is not permitted in this very important patient care vicinity, for the same reason the isolated ground receptacle is able to protect equipment against electromagnetic interference- it is the lack of connections to other grounds (grounded metal such as junction/outlet boxes, and other EGCs that can act as an antenna). The isolated ground wire coming from the isolated ground receptacle has one (and only one) connection to ground, and that is at the electrical panel. Therefore, if that connection at the panel is interrupted or becomes loose, the equipment serving the patient that is plugged into that isolated receptacle would no longer be grounded!

With normal grounding, where the EGC on the receptacle's green screw also has continuity with the metal box (and/or metal conduits; building framing; and other EGCs in the building) there is the possibility of maintaining the safety of an equipment ground, even if one of those connections happens to fail.

Identifying Isolated Receptacles

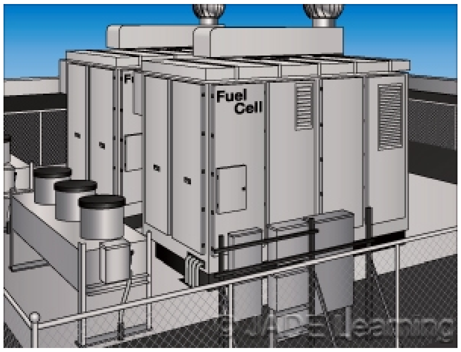
Isolated receptacles are often identified by an orange triangle on the face of the receptacle, or the entire receptacle may be colored orange. The equipment grounding conductor connected specifically to the isolated ground receptacle screw must be green with one or more yellow stripes. The insulated grounding conductor connected to metal boxes and other non-current-carrying conductive electrical equipment must be green or bare ***without*** yellow stripes.

Question 33: The Code says an isolated ground receptacle cannot be installed in the area extending _____ from a patient bed location.

A: 3 ft.
B: 5 ft.
C: 6 ft.
D: 7 ft.

Question 34: 517.30(B)(2) Health Care Facilities. Types of Power Sources. Fuel Cell Systems.

Question ID#: 1183.0



Fuel cells can be used as an emergency source of power for essential electrical systems in hospitals and other health care facilities.

The sources of power permitted for essential electrical systems at hospitals have been relocated from NEC Section 517.35 to Section 517.30. Essential electrical systems for hospitals must have a minimum of two independent sources of power. The normal power source, which is typically an electric utility provider, and one or more alternate sources that can supply the hospital's essential electrical circuits if normal power is interrupted. The most common alternate power source has been one or more prime mover-driven generator sets, but advances in fuel cell technology offer a different alternative.

New to the 2017 NEC, Section 517.30(B)(2) allows for the use of fuel cell systems as an alternate power source for essential electrical systems serving hospitals and other health care facilities.

Fuel cell systems are highly efficient and offer a number of advantages over a prime-mover driven generator set. Fuel cell systems have few moving parts and operate quietly, which can be a plus in a hospital environment. Although there are a number of different fuel cell technologies, all basically use fuels that are rich in hydrogen and produce electricity from electrochemical reactions within the fuel cell. Although fuel cells do produce carbon dioxide, the emissions from a fuel cell are much less than from a generator driven by gas or diesel fuel, so there is less danger from exhaust fumes and less negative impact on air quality.

Many of the requirements included in Section 517.30 were extracted from NFPA 99, ***Health Care Facilities Code***. Additional requirements for installing fuel cell systems in health care facilities can be found in ***Article 692, Fuel Cell Systems.***

In fact, all the requirements in Article 692 are referenced in 517.30(B)(2). Section 692.6 requires fuel cell systems to be listed or field evaluated for the intended application. In addition to the listing and installation requirements of Article 692, section 517.30(B)(2) requires the fuel cell system to be listed for emergency system use and adds five other installation requirements.

The fuel cell system must be able to assume load within 10 seconds upon the loss of normal power and the number of fuel cell units must be one more than the number of fuel cells required to serve the demand loads of the system loads supplied. The fuel cell system must have a continuing source of fuel supply and on-site fuel storage sufficient for the type of essential electrical system. Hydrogen or hydrogen-rich conventional fuels such as methanol, diesel, or gasified coal are all potential fuel sources.

Where a fuel cell system is used as the alternate power source, the performance and capacity requirements extracted from NFPA 99 also include a requirement for the system to provide a connection for a portable diesel generator. The generator connection must be wired to premises wiring so it can supply life safety circuits and equipment, and critical portions of the essential electrical distribution system.

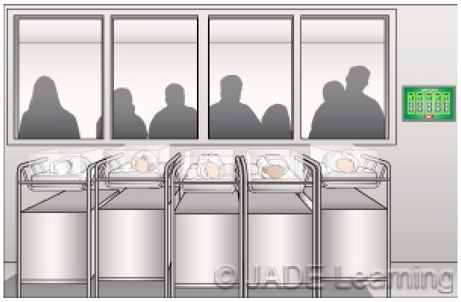
This is similar to the new requirement in 700.3(F). If a legally required emergency system relies on a single alternate power source, 700.3(F) requires permanent switching means to be installed for the connection of a portable or temporary power source so that power can be made available to emergency systems when the emergency generator is out of operation.

Question 34: A fuel cell system that serves as the alternate power source for essential electrical systems in a health care facility must meet which one of the following requirements:

A: Must assume load within 20 seconds.
B: Must be listed for standby use.
C: Must be listed for emergency system use.
D: Must have a connection for a portable gasoline powered generator.

Question 35: 517.34(B) Health Care Facilities. Critical Branch. Switching.

Question ID#: 1184.0



Task lighting on the critical branch of the essential electrical system, such as in an infant nursery, can be controlled by switches or other devices like keypads.

This new subsection permits the control of task illumination on the critical branch of an essential electrical system in a health care facility. Task illumination is different from life safety branch egress lighting where switching is limited to ensure that there is always adequate illumination in exit passageways. The new subsection does not address the form of control for task lighting except that the title of the subsection is "Switching."

The intent is to recognize that many of the areas where task illumination is required, such as pharmacy dispensing areas and hemodialysis rooms are areas that are not in use at all times, and other areas such as infant nurseries and patient bed locations, are areas where lighting would be desired to be at different levels at different times, so illumination should be controllable. Patient comfort could be compromised if there was no control of lighting in some of the patient spaces. Adding the new section makes it clear that task lighting need not be illuminated at all times, but lighting controls will allow the task lighting to be used when needed.

"Task Illumination" is a defined term that was taken from NFPA 99, ***Health Care Facilities Code*** and is defined in Section 517.2 as "Provisions for the minimum lighting required to carry out necessary tasks in the described areas, including safe access to supplies and equipment and access to exits." As defined, some tasks could require different levels of illumination, and some tasks might be performed only occasionally, but the task illumination must still be available when needed. Task illumination may now be connected to the critical branch of the essential electrical system, and the level of illumination can be controlled by switching.

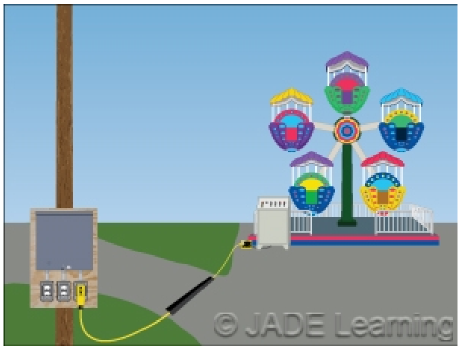
The 2014 NEC already allowed task lighting to be supplied by the critical branch, but the previous wording made it difficult to interpret what switching arrangements were permitted. In some cases, the rules for illumination of the means of egress (exit lighting) were also applied to task lighting. The difference is that illumination in patient corridors can be reduced, but never totally extinguished. There is no need for task lighting to be constantly illuminated when no tasks are being done. With the revised text and the additional wording, the NEC gives specific permission to switch task lighting on and off as needed. This change is part of the desire of the NEC to communicate the code rules in "positive language".

Question 35: How can task illumination on the critical branch be controlled? Â

A: Only by wall switches.Â Â
B: Only by occupancy sensors.Â Â
C: By any means of switching.
D: Only by energy management systems.Â Â

Question 36: 525.23(A) Carnivals, Circuses, Fairs. GFCI Protection & 525.23(D) Receptacles Supplied by Portable Cords.

Question ID#: 1185.0



GFCI receptacles that are supplied by flexible cord must be listed for portable use and the cord must be protected either by a GFCI device that is part of the cord cap, or supplied by a GFCI protected outlet.

Article 525 addresses carnivals, circuses, fairs, and similar events including wiring in or on all structures. GFCI protection for personnel at carnivals and similar events is important for the safety of employees who assemble and operate the equipment and to protect the people who will attend the event. Section 525.23 has been revised to make the GFCI requirements easier to understand.In 525.23(A) the term, "ground-fault circuit-interrupter" has been replaced with GFCI to be consistent with the NEC style manual. A new paragraph, 525.23(D), has been added to address the use of receptacles supplied by branch circuits utilizing flexible cord.

GFCI receptacles supplied by branch circuits utilizing flexible cord must now be listed, labeled, and identified for portable use. GFCI receptacles listed for portable use will trip if the neutral conductor in the supply cord is broken or comes loose in an attachment plug. Ordinary GFCI receptacles do not provide this type of open neutral protection and are not permitted when flexible cord is used as the branch circuit wiring method.

Past practice has been to place a non-portable ordinary type GFCI receptacle in a box and then supply that box with a cord equipped with a male attachment plug. Because itâ€™s not listed for portable use, the GFCI device may not trip when the grounded neutral conductor opens or comes loose at a terminal. This would leave the ungrounded conductor energized. The listing requirements of standard non-portable type GFCI receptacles already prohibited using them in this manner but the extra wording makes the requirement clear in the NEC.

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In addition to GFCI receptacles listed, labeled, and identified for portable use, GFCI protection is permitted to be integral with the attachment plug of a cord, or located in the cord body within 12 in. of the attachment plug. Listed cord sets with integral GFCI protection are also permitted.

Section 525.23(A) All 125-volt, single phase, 15- and 20-amp non-locking type receptacles readily accessible to the general public or used during equipment assembly must be GFCI protected. Any other equipment that is readily accessible to the general public, other than egress lighting, must also be GFCI protected if supplied by a 125-volt, 15- or 20-amp branch circuit. Egress lighting is not permitted to be GFCI protected.

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All 125-volt, single phase, 15- and 20-amp non-locking type receptacles readily accessible to the general public or used during equipment assembly or disassembly must be GFCI protected. Any other equipment that is readily accessible to the general public, other than egress lighting, must also be GFCI protected if supplied by a 125-volt, 15- or 20-amp branch circuit.

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Egress lighting is not permitted to be GFCI protected.

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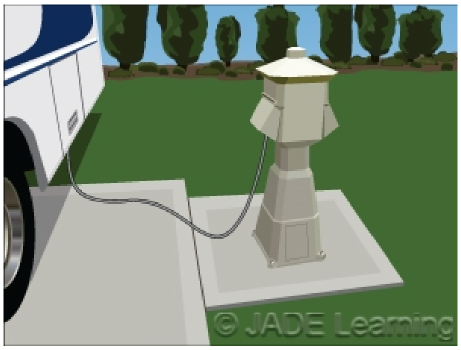
Question 36: At a carnival, which one of the following is NOT an acceptable means of GFCI protection?

A: GFCI protection integral with a listed flexible cord attachment plug.
B: GFCI protection in a listed cord within 12 in. of the attachment plug.
C: A listed, labeled, and identified portable GFCI receptacle.
D: An ordinary GFCI receptacle installed in a device box and supplied by a branch circuit utilizing flexible cord.

Question 37: 551.71 Recreational Vehicle Parks. Type Receptacles Provided.

Question ID#: 1186.0



Every RV site that supplies electric power in an RV park must have at least one GFCI protected 20-amp receptacle. And 70% of RV sites in the park must have a 30-amp receptacle. 40% of new RV sites require a 50-amp receptacle.

Article 551 covers recreational vehicles (RVs) and RV parks, specifically their electrical conductors and equipment other than low-voltage and automotive circuits.

There is no requirement in Article 551 stating that RV camping sites have to be equipped with electric power. However, when sites ***are*** provided with electric power, they must meet the requirements of 551.71.

Every RV site within an RV park capable of supplying electricity to a recreational vehicle must be equipped with the appropriate recreational vehicle site supply equipment and include at least one 125-volt, 20-ampere receptacle. All 125-volt, 15- and 20-ampere receptacles in RV parks, including those at tent sites, must be GFCI protected.

RV site supply equipment that transfers electricity to the RV typically includes one or more receptacles with circuit breaker(s), protected by a hinged weather-resistant cover.

GFCI devices (such as a GFCI receptacle) within RV site electrical supply equipment are not required to be weather-resistant or tamper-resistant. RV electrical supply equipment is NEMA 3R rated and is therefore designed in such a way that it is not necessary to provide weather-resistant receptacles, as the design of the equipment protects the receptacle from weather. The NEC also does not require the receptacles to be tamper-resistant even though small children are often present at a recreational vehicle park.

In addition to the one 125-volt, 20-ampere receptacle that must be included at each RV site with power, 70% of the RV sites within the park with this supply equipment must be equipped with at least one 125-volt, 30-ampere standard RV receptacle. Of course, additional receptacle configurations that comply with 551.81 may also be installed in the RV site supply equipment.

What Else is Required?

In this 2017 Code Cycle, of the preexisting RV sites within the park, no less than 20 percent must include a 125/250-volt, 50-ampere receptacle. For any new RV sites that are erected under the 2017 Code cycle, at least 40 percent of those new sites must be equipped with this 50 amp receptacle. This is because many of the newer RVs are equipped with 50-amp services with 50-ampere supply cords.

It is important to note, the 2017 NEC also says that every RV site that IS equipped with a 50-ampere receptacle must also be equipped with a 125-volt, 30-amp standard RV receptacle. Using the 2017 NEC as our guide, we should not see any RV hookup equipment within an RV park containing a 50-amp receptacle but no 30-amp receptacle.

Tent Sites in the RV Park

Tent sites in an RV park, when equipped with 15- or 20-ampere receptacles can be excluded when determining the percentage of RV sites that require 30-ampere or 50-ampere receptacles. Remember, 70% of the RV hookup sites in the park have to include a 30-amp receptacle. 20% of the older preexisting RV hookup sites have to include a 50-amp receptacle. And 40% of newly constructed RV hookups within the park must include a 50-amp receptacle. Tent sites have no bearing on these percentages, as tent sites are ***NOT*** RV hookup sites. Note: The load for each tent site when calculating the electrical service for an entire RV park is 600 VA per tent site.

Informational Note

The number of 50-amp receptacles required in 551.71 may not be sufficient for all RV parks all the time. The Informational Note that follows 551.71 reminds us that even having 40% of the RV sites equipped with a 50-amp receptacle may still not be enough for some RV Parks during peak usage. RV parks in popular locations are often occupied by a higher percentage of larger, newer RV's that require the larger 50 Amp service.

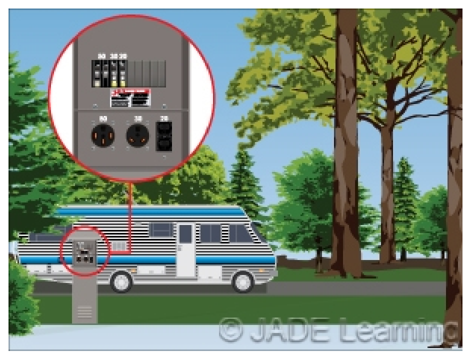
Question 37: In a brand-new RV park built under the authority of the 2017 NEC, how many of the RV hookup sites must be equipped with 125/250-volt 50 amp receptacles when all 100 sites are equipped with electric power?

A: 100 sites.
B: 70 sites.
C: 30 sites.
D: 40 sites.

Question 38: 551.73(A) RV Parks. Calculated Load. Basis of Calculations.

Question ID#: 1187.0

The Electrical Service supplying an entire RV Park, must be sized to accommodate the electrical demands of multiple modern recreational vehicles drawing power simultaneously from the individual park ***sites***. The sum of the individual sites within the park, ***with some additional math applied***, determines the total service size for the park.



When calculating the service size for an entire RV Park, the sum of the electrical loads at the individual RV sites are determined first, before applying a demand factor to the entire park's service ampacity.

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Per the 2017 NEC, when calculating an RV park service, the load that you count for a single RV site equipped with a 125/250 volt, 50-ampere receptacle, has been increased from ***9600 volt-amperes to 12,000 volt-amperes***. The load you count for a single RV site equipped with both 30-ampere and 20-ampere receptacles remains unchanged at 3600 volt-amperes. The load counted for a 20-ampere RV site receptacle is 2400 volt-amperes. And the load counted for each 20-amp supply provided at each dedicated tent site is 600 volt-amperes.

The individual RV sites within an RV park are equipped with "supply-equipment," so that the RVs can connect to the available electric. These individual supply enclosures typically consist of more than one receptacle. When a multi-receptacle supply enclosure is designed to serve just a single RV at that site, the load that you count toward determining the size of the entire park service is based on the single highest rated receptacle within that multi-receptacle enclosure. For example, if it contains a 50-ampere as well as a 20-ampere receptacle, you would only count the 50-ampere. However, where the supply enclosure is expected to serve ***two recreational vehicles***, the load you count toward sizing the park service is calculated using the ***two*** highest rated receptacles within that enclosure, not just the one.

After adding up all the sites in the park, the next step is to apply a demand factor from Table 551.73(A) to that total. This demand factor allows the electrician to use a lesser value than the sum of all the RV sites added together, when calculating the service for the entire RV park. The logic here is that the more RV sites there are in the park, the less likely it is that all of them will be used at once. For example: The demand factor for a service supplying just one RV site is 100%, which is just another way of saying that there is no allowable demand factor at all. The demand factor for a service supplying two RV sites is 90%. Three RV sites is 80% and so on. And when you reach 36 or more sites in the park, the demand factor is 41%, regardless of how many sites there are beyond 36. This means if you had 36 or more RV sites in the park, you would take the sum of all RV sites and only use 41% of that number when deciding how big the park's electrical service has to be. This is a real money-saver when designing an electrical service for such a location. It is important to note: The generous demand factors from the Table ***are not*** to be applied to loads such as ***RV park bathrooms***, ***recreational buildings, swimming pools or similar amenities***. These locations are calculated separately.

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Here is an RV Park, Service Calculation Example. There are 60 Sites Total and here is the Breakdown:

20 Sites. Each site is designed to power one RV. Each site is equipped with:

One 50-ampere, 125/250-volt receptacle.

One 30-ampere, 125 volt receptacle.

One 20-ampere, 125 volt receptacle.

You just count the largest receptacle of the three, which is the 50-ampere: (20 sites x 50 amp receptacles, worth 12,000va each: 20 x 12,000= ***240,000 va***)

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15 Sites. Each site is designed to power one RV. Each site is equipped with

One 30-ampere, 125 volt receptacle.

One 20-ampere, 125 volt receptacle.

Remember, when both 20-ampere and 30-ampere receptacles are present at one site, the value is 3600VA: (15 sites x 3600va = ***54,000va***)

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15 Sites. Each site is designed to power one RV. Each site is equipped with

One 20-ampere, 125 volt receptacle.

A 20-ampere receptacle is worth 2400va: (15 sites x 2400va= ***36,000va***)

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10 Sites for tent camping, each equipped with 20amps of power:

Each tent site supplied with 20amps, counts as 600va: (10 sites x 600va = ***6000va)***

TOTAL VA FOR THESE 60 SITES= ***336,000va***

Demand Factor from Table 551.73(A) is 41 % for 36 or more RV sites, so 336,000 x 41% =____

137,760 VA

Turning volt-amps (VA) into amps for determining the service size.

If the RV park service is going to be 120/240 single phase, then the minimum ampacity for that service would be determined by taking that 137,760 VA and dividing it by 240 V = 574 AMPS

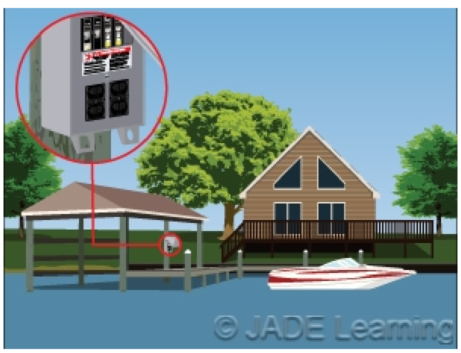
A 600 Amp service would be adequate.

Question 38: An RV Park has 30 sites all equipped with a 125/250-volt 50-ampere receptacle. The demand factor for 30 sites, from Table 551.73(A) is 42%. What is the total calculated load for the RV sites?

A: 360,000 volt-amperes.
B: 12,000 volt-amperes.
C: 151,200 volt-amperes.
D: 108,000 volt-amperes.

Question 39: 555.1 Marinas, Boatyards, and Commercial and Noncommercial Docking Facilities. Scope.

Question ID#: 1188.0



Article 555 now covers docking facilities at one-family dwellings, two-family dwellings, multifamily dwellings, and residential condominiums.

The title of Article 555 has changed from ***Marinas and Boatyards*** to ***Marinas, Boatyards, and Commercial and Noncommercial Docking Facilities.*** The scope of Article 555 has been expanded to include docking facilities at one-family dwellings, two-family dwellings, multifamily dwellings, and residential condominiums. The exclusion for docks associated with a single-family dwelling has been deleted.

The electrical hazards associated with a boat dock are essentially the same, regardless as to whether the boat dock is at a commercial or noncommercial docking facility. Numerous electrocutions and electric shock drownings have been reported at residential docking facilities. Expanding the scope of Article 555 to include docks associated with single-family dwellings and other noncommercial docking facilities will increase electrical safety. The change also eliminates confusion over the electrical requirements for noncommercial docking facilities associated with multifamily dwellings. The installation requirements in Article 555 now apply to all docking facilities used for the repair, berthing, launching, storage, or fueling of small craft and the moorage of floating buildings.

For example, all overcurrent devices supplying a commercial or noncommercial docking facility, marina or boatyard must have ground-fault protection not exceeding 30 mA in accordance with 555.3. All equipment grounding conductors must be insulated and sized in accordance with 250.122, but not smaller than No.12 AWG. Equipment grounding conductors No. 6 AWG and smaller must be identified by an outer finish that is green or green with one or more yellow stripes.

Wiring methods in Chapter 3 that are identified for use in wet locations are permitted, but must include an insulated equipment grounding conductor. Extra-hard usage portable power cable is permitted to be used on the underside of piers and where flexibility is required, but must be listed for both wet locations and sunlight resistance. Wiring above the pier deck must be protected using rigid metal conduit, RTRC conduit listed for above ground use, or rigid PVC conduit.

Rather than include docking facilities at one- and two-family dwellings in article 555, another article could have been developed just for these residential docking facilities, but this option would have created two articles with essentially the same requirements. The same electrical hazards are present at a noncommercial docking facility associated with one or more dwelling units as at a commercial boat dock. It is logical that the electrical wiring at these noncommercial docks is held to the same electrical safety standard as a commercial facility.

Question 39: Which one of the following is NOT included in the scope of Article 555?

A: Receptacles on a floating dock at a single family dwelling.
B: Lighting on a dock at a residential condominium.
C: Docking facilities at a commercial boatyard.
D: Wiring inside of a boat.

Question 40: 555.3 Marinas, Boatyards, and Commercial and Noncommercial Docking Facilities. Ground-Fault Protection.

Question ID#: 1189.0

GFCI protection with trip settings at 30 mA are required for overcurrent protective devices that supply residential docking facilities.

Electric shock has been a contributing factor in a number of drownings in the waters around both commercial and noncommercial docking facilities. A study by the American Boat and Yacht Council determined that the 100-mA ground-fault protection required in the 2014 NEC did not provide adequate shock protection for swimmers or other persons in the water around a boat dock.

Overcurrent protective devices that supply marinas, boatyards, and commercial and noncommercial docking facilities must now have ground-fault protection not exceeding 30-mA. Providing ground-fault protection at the supply end of the circuit ensures that the entire length of the circuit is protected.

Docking facilities at one-and two-family dwellings, multifamily dwellings and residential condominiums are included in the scope of Article 555. All overcurrent protective devices that supply residential docking facilities must now also have ground-fault protection not exceeding 30-mA. The 30-mA protection requirement for the circuits that feed the docking facilities is not low enough to protect a person if all of the 30-mA current were to flow through their body, but studies have shown that ground-fault protection in the 30-mA range will provide an acceptable level of protection to a swimmer because the water offers multiple current paths.

The American Boat and Yacht Council (ABYC) now requires 30-mA current leakage protection on boats built to ABYC standards. However, not all boats are built to ABYC standards and ground-fault protection aboard the boat will not protect the wiring on the boat dock(s).

The 30-mA ground-fault protection for feeders and branch circuits is not a substitute for GFCI protection for personnel required by other code sections. For example, 210.8(C) requires boat lifts rated 240 volts or less to have GFCI protection for personnel where installed at a dwelling. Section 555.19 requires GFCI protection for personnel for all 15- and 20-ampere, 125-volt receptacles installed outdoors, in boathouses, or in buildings or structures used for storage, repair, or maintenance. GFCI receptacles or GFCI circuit breakers may be used. In many cases the GFCI protection will be provided within a listed marine power outlet that also includes the shore power receptacle.

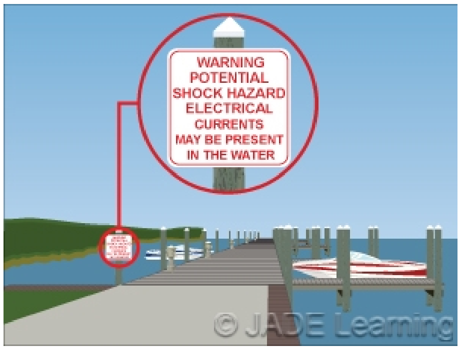
GFCI protection for personnel must be provided by a Class A GFCI device, such as a GFCI receptacle or GFCI circuit breaker, that will trip when the current to ground is in the 4 to 6 mA range. A Class A GFCI circuit breaker can be used to meet the 30-mA ground-fault protection requirement for circuits supplying boat docks, but the lower mA rating may result in nuisance tripping.

Question 40: What is the maximum ground-fault trip rating for a 100-amp overcurrent device supplying a panelboard on a boat dock?

A: 100 amps.
B: 5 mA.
C: 100 mA.
D: 30 mA.

Question 41: 555.24 Marinas, Boatyards, and Commercial and Noncommercial Docking Facilities. Signage.

Question ID#: 1190.0



Signs around a marina or docking facility must warn swimmers that there is a potential shock hazard from electrical currents in the water.

Swimming around a marina or other docking facility can be hazardous for a number of obvious reasons. One of the least visible is the danger of electric shock drowning. Electric shock while swimming has resulted in numerous drownings at marinas and other docking facilities in recent years. All overcurrent protective devices supplying marinas, boatyards, and commercial and noncommercial docking facilities are required by the 2017 NEC to have ground-fault protection, but it is also important to raise public awareness of the potential shock hazard in the water around docking facilities.

Electric shock drowning can occur in the water around any boat dock, but the danger is higher in fresh water than in salt water. When swimming in fresh water, the human body offers a lower resistance to electric current than the surrounding water. Salt water typically offers much less resistance and this allows the electrical current to flow around instead of through the swimmerâ€™s body. Faulty wiring or deteriorated power supply cords can create currents in fresh water a considerable distance from the electrical fault. If a swimmer enters the energized area the currents will pass through their body and cause the muscles to contract. The swimmer will be unable to swim and the result is an electric shock drowning.

There are many reasons to enter the water around a docking facility other than recreational swimming. Marina maintenance staff, boat owners, and divers should all be alerted to the electric shock hazard that may be present in the water. If there is a need to enter the water to work on a boat or dock appropriate safety precautions should be taken including locating the disconnecting means for the electrical circuits. There are testing devices available that will detect the presence of electrical currents in the water, but the safest precaution is to de-energize circuits in the vicinity. There should also be someone on the dock or shore that can make an emergency call if needed.

A simple and inexpensive way to inform maintenance staff, boat owners and the public of the potential hazard in the water around boat docks and marinas is by posting warning signs advising that electric currents may be present in the water. Warning signs are now required to be posted and clearly visible from all approaches to a marina or boatyard. Logically, this would include both land and water approaches to the boat docks. Other docking facilities covered by Article 555 include boat docks at one- and two-family dwellings, multi-family dwellings and residential condominiums.

The required wording for the warning sign is:

WARNING

-POTENTIAL SHOCK HAZARD-

ELECTRICAL CURRENTS MAY BE PRESENT IN THE WATERÂ

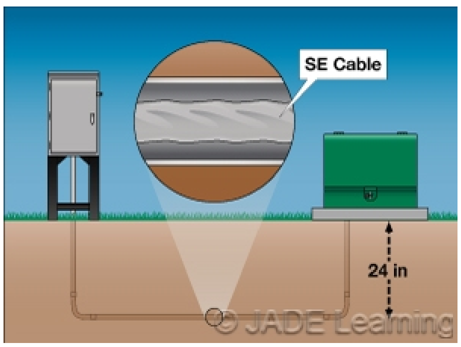
The warning signs must be suitable for the harsh environment typically associated with facilities on the water and must comply with 110.21(B)(1). Guidelines for warning signs can be found in ANSI Z535.4-2011, but the important point is that the signs be clearly visible. It would be best to confirm specific sign requirements and locations with the local authority having jurisdiction before installing the signs.

Question 41: At a marina or boat yard, signs advising of the POTENTIAL SHOCK HAZARD shall include which of the following key word(s)?

A: CAUTION.
B: DANGER.
C: WARNING.
D: NO SWIMMING.

Question 42: 590.4(B),(C),(G) Temporary Installations. General. Feeders, Branch Circuits, Splices.

Question ID#: 1191.0



In temporary installations SE cable can be installed in a raceway underground. NM cable can spliced in temporary installations without a box as long as the continuity of the equipment grounding conductor is maintained.

Article 590 addresses temporary installations including temporary electric power and lighting installations. The rules in section 590.4(G) about making splices in temporary wiring no longer apply just to construction sites. The rules have changed and now apply to all temporary wiring installations.

When a junction box is used, a cover is now required to be installed on the junction box.

A junction box is still not required for splices when nonmetallic sheathed cable or cord is used, as long as the equipment grounding continuity is maintained with or without the box. All of the conductors being spliced must be from nonmetallic cords or nonmetallic cable assemblies.

Also, a new requirement was added for when metal sheathed cable is spliced in a temporary installation. A junction box is not required when metal sheathed cable is terminated with the appropriate listed fittings to mechanically secure the cable sheath and maintain the electrical continuity of the cable sheath. However, all conductors involved in the splice must be from metal sheathed cables if a box is not used for the splice.

In section 590.4(B) &(C), SE cable is now permitted to be installed in temporary installations for feeders or branch circuits. SE cable used for temporary feeders and branch circuits is also permitted to be installed in a raceway for underground installations.

Other wiring methods permitted for temporary branch circuits and feeders include multiconductor cords or cables identified in Table 400.4 for hard-usage or extra-hard usage and Type NM and Type NMC nonmetallic cables.

The exception to 590.4 (C) allows single conductors to be used for certain types of temporary wiring. Temporary wiring for holiday decorative lighting that is left up for no more than 90 days and wiring for tests or emergencies may use single conductors. Where single conductors are used, the voltage to ground must not exceed 150 volts.

Temporary branch circuits must originate in an approved power outlet, switchgear, switchboard or panelboard, motor control center, or fused switch enclosure.

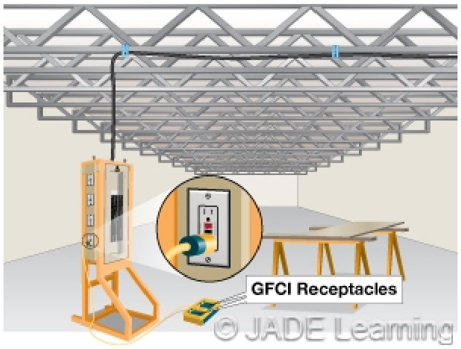
Question 42: For temporary installations covered by Article 590 in the 2017 NEC, where do the requirements for splicing multiconductor cable apply?

A: Only to residential construction sites.
B: Only to commercial construction sites.
C: Only in wet locations.

D: To all temporary wiring installations.

Question 43: 590.6(A)(1) GFCI Protection for Personnel. Receptacle Outlets. Receptacle Outlets Not Part of Permanent Wiring.

Question ID#: 1192.0



Listed portable cord sets can be used to provide GFCI protection in temporary installations. The cord for the portable cord set must be GFCI protected also, either by a GFCI device made into the cord set or by a GFCI protected receptacle.

Section 590.6 applies only to temporary wiring installations used to supply temporary power to equipment used by workers during construction, remodeling, maintenance, repair, or demolition of buildings or structures.

Temporary receptacles are often installed during construction, remodeling, or similar activities. All 125-volt, single-phase 15-, 20-, and 30-ampere receptacle outlets that are not part of the permanent wiring of the building must have GFCI protection for personnel. The change to 590.6(A)(1) is intended to clarify that GFCI protection is required for temporary receptacles that are not part of the permanent wiring of the building. The language in the 2014 NEC was not clear and appeared to permit temporary receptacles to be installed without GFCI protection if listed cord sets with built-in GFCI protection were used. This was not the intent.

For temporary installations, if the temporary receptacle outlet is GFCI protected, then any cord set plugged into that outlet will have GFCI protection. Temporary receptacles on construction sites are typically used by many different construction crews with various types of equipment. Some equipment may be plugged directly into a receptacle. Some crews may use listed portable GFCI cord sets, but others may not. If GFCI protection is not provided at the receptacle, there is no guarantee that GFCI protection will be provided and workers may be exposed to electric shock hazards.

GFCI protection can also be provided by listed cord-sets that are identified for portable use, but the temporary receptacle that the GFCI cord set is plugged into must be GFCI protected itself. Using a portable cord-set that has GFCI protection built into it is not a substitute for having a GFCI protected receptacle where the cord set is plugged in.

The use of listed portable GFCI cord sets or devices is still permitted, but not as a substitute for GFCI protection of temporary receptacles.

The language in 590.6(A)(2) concerning the use of receptacles that are part of the permanent wiring system remains unchanged. All 125-volt, 15-, 20-, and 30-ampere receptacles that are part of the permanent wiring system must be provided with GFCI protection if used for temporary power. Listed GFCI protected cord sets or devices identified for portable use are permitted.

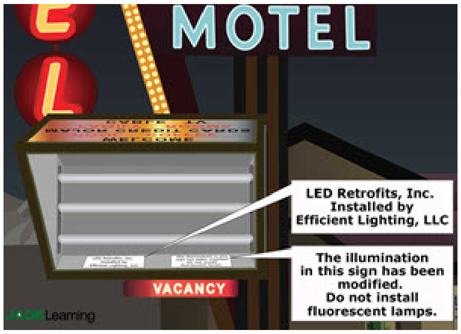
Question 43: Which of the following is true about the use of listed cord sets that include integral GFCI protection when used with 20-ampere, 125-volt temporary receptacles installed inside a building for construction purposes?

A: The listed cord set is permitted to be the only GFCI protection.Â Â Â
B: The listed cord set is permitted to be used only in addition to GFCI protected temporary receptacles.
C: The listed cord set is not permitted to be used for any temporary wiring.
D: The listed cord set is not permitted to be used with GFCI protected receptacles.

Chapter 6

Question 44: 600.4(B) Electric Signs and Outline Lighting. Markings. Signs with a Retrofitted Illumination System.

Question ID#: 1193.0



Electric signs with a retrofitted illumination system must be field marked with warning labels and the name of the installer that performed the retrofit.

Chapter 6 of the NEC covers Special Equipment. Article 600 is about Electric Signs and Outline Lighting, and 600.4 addresses Markings. Many fluorescent lighted signs are being retrofitted with light-emitting diodes (LED's). New Section 600.4(B) requires markings to be placed on the sign stating the illumination system has been replaced. The marking must include the retrofit kit provider and installers name, logo or unique identifier.

When retrofitted tubular LED lamps are powered by existing fluorescent lamp sockets in the sign, an additional label is required that alerts service personnel the sign has been modified. The label must include language warning technicians not to install fluorescent lamps. This label must be visible during relamping and comply with Section 110.21(B), Field-Applied Hazard Markings.

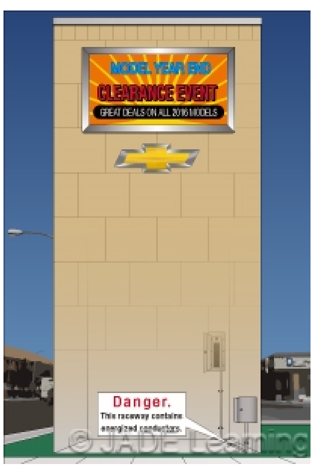
Once a fluorescent Illumination system has been retrofitted to work with tubular LED's, if fluorescent tubes are installed in the modified luminaire, the fluorescent lamps could explode. The new requirement to install a warning label should prevent an installer from being injured by exploding fluorescent lamps.

Question 44: A retrofitted sign must include marking with the name, logo or unique identifier of the kit supplier and the ___________?

A: Owner.
B: Customer.
C: Installer.
D: Utility company.

Question 45: 600.6(A) Electric Signs and Outline Lighting. Disconnects. Location.

Question ID#: 1194.0



A disconnect is not required at the entrance to an electric sign if a warning label is installed that says, â€œDanger. This raceway contains energized conductors.â€•

600.6 discusses the disconnect requirements for sign and outline lighting systems. Section 600.6(A) has been expanded to change the location requirements for a sign disconnect.Â

A new ***Exception*** was added stating a disconnect is not required at the point of entry of the sign for branch circuit(s) or feeder conductors supplying an internal panelboard.Â

A permanent warning label must be applied to the raceway at or near the point of entry of the sign and state***: â€œDanger. This raceway contains energized conductors.â€•***

600.6(A)(3) has a new ***Exception*** permitting the disconnect to be installed out of sight from the controller when a label identifying the location of the disconnecting means is applied and visible during servicing.

In all cases, labeling must be permanent and visible during servicing and must state the location of the disconnecting means.Â All disconnects must be lockable in the open position.

Many large signs are computer controlled and the controller is located out of sight of the sign.Â The disconnect for the controller must disconnect the sign or outline lighting system and the controller from all ungrounded supply conductors. The new exception will permit the disconnecting means for the controller to be out of sight of the controller, as long as a label is attached to the controller that identifies the location of the disconnecting means.

Question 45: What type of information is required for a label at an electric sign when the sign disconnect is not visible from the sign?

A: The voltage rating of the disconnect.
B: The type of disconnect.
C: The location of the disconnect.
D: The amperage rating of the disconnect.

Question 46: 600.33 Electric Signs and Outline Lighting. Class 2 Sign Illumination Systems, Secondary Wiring.

Question ID#: 1195.0

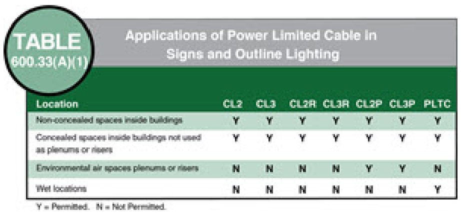


TABLE 600.33(A)(1) Applications of Power Limited Cable in Signs and Outline Lighting

Location	CL2	CL3	CL2R	CL3R	CL2P	CL3P	PLTC
Non-concealed spaces inside buildings	Y	Y	Y	Y	Y	Y	Y
Concealed spaces inside buildings not used as plenums or risers	Y	Y	Y	Y	Y	Y	Y
Environmental air spaces plenums or risers	N	N	N	N	Y	Y	N
Wet locations	N	N	N	N	N	N	Y

Y = Permitted. N = Not Permitted.

New Table 600.33(A)(1) lists the environmental conditions where Class 2 cable types used in signs and outline lighting are permitted or not permitted.

Some of the changes made to this and related Code sections include:

- The title of Section 600.33 has been changed from ***LED Sign Illumination Systems*** to ***Class 2 Sign Illumination Systems*** because the Section now covers ALL Class 2 lighting and lighting connected to a Class 2 power source within a sign, instead of just LED's.

- The reference to Article 725 Class 1, Class 2, and Class 3 Remote-Control, Signaling and Power-Limited Circuits was removed altogether.

- New Tables are now added for wire types used for secondary circuitry wiring:

(1) ***Table 600.33(A)(1) - Applications of Power Limited Cable in Signs and Outline Lighting*** &

(2) ***Table 600.33(A)(2) - Class 2 Cable Substitutions.***

- Also, 600.33(A)(3) has removed the term "moisture-impervious sheath" as one of the approved cable-characteristics, it now says: ***"Class 2 cable shall be listed and marked suitable for use in a wet location."*** However, do not mistake this to mean that all Class 2 cable is approved for wet locations as it is not per the Table. But if a Class 2 cable is to be used in a wet location, the Code is simply saying it must be marked as approved for wet locations.

- Finally, in 600.33(A)(4) the reference to Table 725.154 was removed and the new text says "***Class 2 cable exposed to sunlight shall be listed and marked sunlight resistant suitable for outdoor use."***

Question 46: For signs and outline lighting, where is a power limited cable, Type CL2, permitted to be used?

A: Non-concealed spaces inside of buildings.
B: Concealed spaces inside buildings that are used as plenums or risers.
C: Environmental air spaces, plenums or risers.
D: Wet locations.

Question 47: 600.34 Electric Signs and Outline Lighting. Photovoltaic (PV) Powered Sign.

Question ID#: 1196.0

New rules apply to photovoltaic (PV) powered signs.

Section 600.34 is new in the 2017 NEC and provides specific requirements for wiring PV powered signs. It includes sections (A) Equipment, (B) Wiring, (C) Flexible Cords and Cables, (D) Grounding, (E) Disconnecting Means, and (F) Battery Compartments.

All non-grid and on-grid variations of PV powered signs are covered.Â Equipment such as wiring, inverters, PV modules, ac PV modules, dc combiners, dc-ac converters and charge controllers used in a PV powered sign must be listed for use in a PV application.Â

The disconnecting means for a PV powered sign does not need to be listed for use in a PV application but must comply with Article 690, Part III andÂ 600.6.

External wiring must be routed as short as possible to closely follow the sign body.Â The wiring must also be secured at intervals not exceeding 3 feet and protected from physical damage.

If flexible cords or cables are used, they must be identified as extra hard usage, rated for outdoor use and water and sunlight resistant.Â

When a storage battery compartment is used, a tool is required to open the battery compartment.Â

Question 47: Wiring installed on the exterior of the sign body must be secured at intervals not exceeding ________ feet?

A: 6 feet.
B: 4 feet.
C: 3 feet.
D: 2 feet.

Question 48: 620.16 Elevators, Dumbwaiters, Escalators, Moving Walks, Lifts, & Chairlifts. Short-Circuit Current Rating.

Question ID#: 1197.0

Elevator control panels must be marked with a short-circuit current rating.Â The short-circuit current rating of the equipment must be greater than the available short-circuit current.

Article 620 covers Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts. Section 620.16 is new and addresses short-circuit current rating. This new section requires elevator control panels to be marked with a short-circuit current rating. The short circuit current rating may be based on the marking of a listed assembly, or it may be determined using an approved method. One approved method is a calculation based on a UL Standard for industrial control panels.Â That standard considers the ratings of individual components and the type and rating of an overcurrent device or devices protecting the control panel.Â Of course, a method is approved only if it is acceptable to the Authority Having Jurisdiction.

Notice that the requirement in 620.16(A) is for a marking.Â The advantage of a marking is that it provides a basis for determining whether a basic requirement that applies to all electrical equipment is met.Â That is, the requirement of Section 110.10 that all equipment must be selected and applied so that an overcurrent device protecting the circuit and equipment can operate to clear a fault â€œwithout extensive damage to the electrical equipment of the circuit.â€•

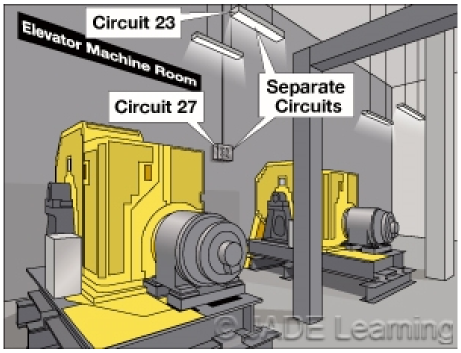
That basic requirement is essentially repeated in 620.16(B) which says the elevator control equipment may not be installed where the available fault current exceeds the short-circuit current rating of the control panel.Â The rule applies regardless of whether the equipment is marked or not, but marking allows an AHJ to judge whether an installation is adequate.Â Marking also helps the installer make sure that the equipment being installed is rated correctly and the short-circuit rating is equal to or greater than the available fault current.

Question 48: A new requirement in Article 620 requires which of the following for an elevator control panel?

A: A marking of the available short-circuit current.
B: A marking of the interrupting rating.
C: A marking of the short-circuit current rating.
D: A marking that says the control panel is approved.

Question 49: 620.23(A) & 620.24(A) Elevators, Dumbwaiters, Escalators, Moving Walks, Lifts, & Chairlifts. Separate Branch Circuits.

Question ID#: 1198.0



In elevator control spaces one dedicated circuit must supply lighting and a separate circuit must supply the receptacles in the area.
Â

Sections 620.23(A) and 620.24(A)address Separate Branch Circuits. These sections have been clarified to require separate branch circuits for lighting and receptacles.Â At least two branch circuits are required for machine rooms, control rooms, machinery spaces, and control spaces for elevators or dumbwaiters. At least two more branch circuits are required for lighting and receptacles in the hoistway pit.Â In each case, one circuit must supply only lighting in these spaces and a separate circuit must be used only for receptacles in the spaces. These circuits may not supply any other loads.Â

The required circuits are in addition to any required for lighting, receptacles, air conditioning, ventilation, or any other utilization equipment for the elevator car or cars. The receptacles are required to have GFCI protection for personnel.Â However, GFCI protection is not permitted for the circuit that supplies power to required lighting.Â The purpose of these requirements is to ensure that lighting will not be disconnected by a ground-fault or short-circuit on the receptacle circuits.

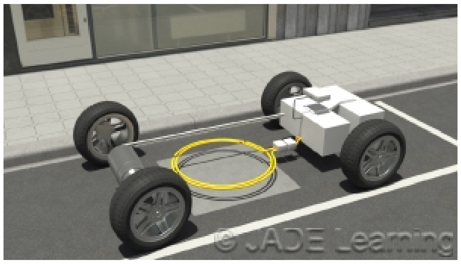
Based on these requirements, every elevator installation must have at least five separate branch circuits provided for receptacles and lighting.Â Two circuits are required for lighting, one for the machine or control space or room and one for the hoistway pit.Â Two circuits are required for receptacles, again, one for the machine or control space or room and one for the hoistway pit.Â In addition, at least one circuit is required for car lighting and receptacles, and more circuits may be required if heating or air-conditioning equipment is used. More circuits may be required if there are additional and separate hoistways or separate machine or control spaces.Â Â

Question 49: Which of the following IS NOT required to be supplied by a separate circuit that supplies no other loads?

A: Receptacles in hoistway pits.
B: Receptacles in elevator machine rooms.
C: Car lighting and receptacles.
D: Receptacles in elevator lobbies.

Question 50: 625.1 Electric Vehicle Charging System. Scope.

Question ID#: 1199.0



Electric vehicles can be charged by inductive, or wireless, charging. With inductive charging there is wireless power transfer between the charging unit and the vehicle.

Article 625 is a newer article in the NEC that covers Electric Vehicle Charging Systems. Electric Vehicles still make up a very small part of the U.S. market, but it is growing. California is the largest market in the United States, making up about 48% of plug-in vehicle sales in the U.S. from 2011 to 2016. Section 625.1, which covers inductive and conductive means of charging electric vehicles, has been expanded to include new wireless charging technology. A new term, wireless power transfer (contactless inductive charging), has been added to the text.

Wireless power transfer is commonly used to charge cell phones today. This technology is now also used to charge electric vehicles using an inductive mat under the car to wirelessly charge the battery.

There is no direct contact between the vehicle and the charging system. The inductive charge is picked up by an undercarriage unit in the vehicle and routed to the car battery. The battery can be charged simply by parking the car over the inductive charging unit. The downside of the technology is that it is relatively low power and low efficiency.

The term "conductive" was added in ***Informational Note 2*** to indicate the existing UL Standards do not cover wireless power transfer.

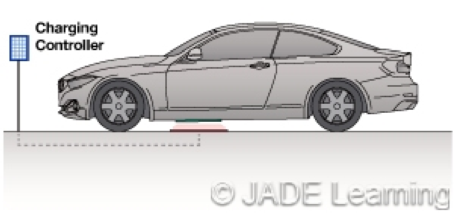
The scope of Article 625 has changed to include conductive, and inductive, or wireless power transfer, charging for electric vehicles.

Question 50: The new term "wireless power transfer" is also referred to as what type of charging?

A: Contactless inductive charging.
B: Trickle charging.
C: Fast charging.
D: Bypass charging.

Question 51: 625.2 Electric Vehicle Charging System. Definitions.

Question ID#: 1200.0



Wireless Power Transfer and Wireless Power Transfer Equipment are new definitions in Article 625. Wireless power transfer is the inductive transfer of power between a primary and a secondary device.

New definitions of Wireless Power Transfer and Wireless Power Transfer Equipment have been added to Article 625, Electric Vehicle Charging Systems. Wireless Power Transfer (WPT) is defined as "The transfer of electrical energy from a power source to an electrical load via electrical and magnetic fields or waves by a contactless inductive means between a primary and secondary device." Wireless Power Transfer Equipment (WPTE) is defined as "Equipment consisting of a charger power converter and a primary pad.
The two devices are either separate or contained within one enclosure." These two new terms are necessary for the application of a new Part IV in Article 625 that covers this type of equipment.

The new terms and the rules relating to this equipment were added to the NEC in anticipation of this technology becoming available for charging electric vehicles. The definitions and installation requirements are based on standards being developed by SAE, an engineering group that produces standards for the automotive and aerospace industries.

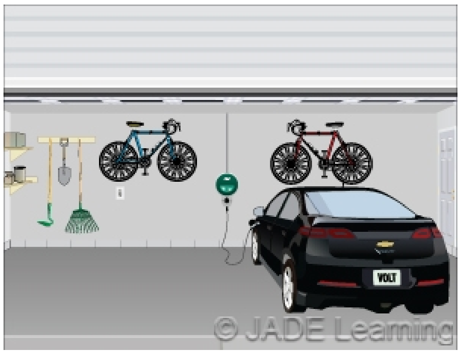
The concept and physical science behind this technology are well established. It is based on the same techniques that have been used in transformers for a very long time and more recently in charging systems for small batteries used in some small electronic devices. It would allow a vehicle equipped with the appropriate secondary device to be charged by close proximity to a primary pad but without requiring the vehicle to be plugged in or otherwise physically connected. Theoretically it could be used to power vehicles without batteries, but in the context of Article 625 it is for charging batteries in vehicles.

Question 51: According to the definition of Wireless Power Transfer, the transfer of electrical energy is "by a ________________________ between a primary and secondary device."

A: Self-induction.
B: Capacitive coupling.
C: Contactless inductive means.
D: Circuit impedance.

Question 52: 625.40 Electric Vehicle Charging System. Electric Vehicle Branch Circuit.

Question ID#: 1201.0



Each outlet installed for the purpose of charging electric vehicles must be supplied by an individual branch circuit.

The requirements for electric vehicle branch circuits have been relocated from 210.17 to a new section 625.40. The wording has also been revised to eliminate confusion over the number of outlets permitted on the electric vehicle branch circuit.

Each outlet installed for the purpose of charging electric vehicles shall be supplied by an individual branch circuit. (625.40)

This is a change from the previous language in 210.17 that referred to ***outlet(s)*** supplied by a separate branch circuit. The code is now clear that only one outlet is permitted on each individual branch circuit installed for the purpose of charging an electric vehicle. No other outlets are permitted on the branch circuit.

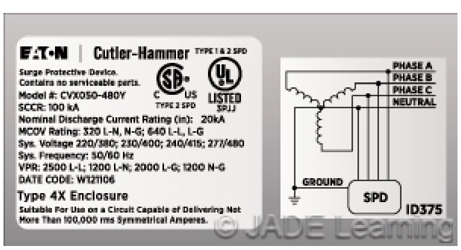
The term outlet includes both a receptacle outlet and equipment connected by permanent means. Both stationary and portable cord-and-plug connected electric vehicle charging systems are available. Electric vehicle charging is considered a continuous load for the purposes of Article 625. The individual branch circuit must be rated not less than 125% of the maximum charging load.

Question 52: A new car dealer installs 2 electric vehicle charging systems rated 16 amperes each. Which one of the following branch circuit(s) is the minimum required?

A: One 40-ampere branch circuit.
B: Two 20-ampere branch circuits.
C: Two 15-ampere branch circuits.
D: One 35-ampere rated branch circuit.

Question 53: 645.18 Modular Data Centers. Surge Protection for Critical Operations Data Systems.

Question ID#: 1202.0



Surge protection is required for Informational Technology Equipment that is used for critical operations data systems like 911 emergency call centers.

With this change, Information Technology Equipment (ITE) data systems that are installed in rooms complying with Article 645 and used for critical operations data systems are required to be provided with surge protection. Many installations of information technology equipment are not covered by Article 645, but surge protection is required at all voltage levels in Critical Operations Power Systems (COPS) according to Article 708.

Information Technology Equipment rooms and equipment that are not used for COPS data are not required to have surge protection. The requirements for the installation of surge protective devices (SPDs) are covered in Article 285. The design of the surge protective system is not dictated in the NEC, but the requirements of Article 285 must be followed.

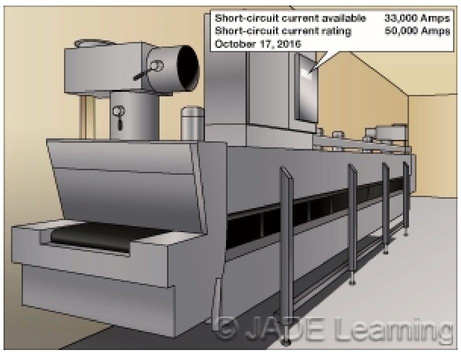
This new requirement is one of a series of requirements added in the 2017 NEC for emergency systems. These additional requirements apply to equipment that may be classified as emergency system loads or otherwise considered to be essential in emergency situations. The loads may be elevators, industrial equipment, fire pump controllers, emergency systems, and power supplies that are part of COPS. In each case the concern is that an electrical voltage impulse could disable the system. In the case of Article 645, that would be the power supply for a data system where the loss of the operation of the system and interruption of the availability of data could disrupt national security, the economy, or public health or safety. Typically, the determination that a system is critical is made by governmental authorities.

Question 53: The surge protection required in Article 645 applies to which one of the following?

A: All information technology equipment installed within an Information Technology Equipment Room.
B: All data systems equipment installed outside of rooms covered by Article 645.
C: All Critical Operations Data Systems installed in a room covered by Article 645.
D: All data systems other than Critical Operations Data Systems.

Question 54: 670.5 Industrial Machinery. Short-Circuit Current Rating.

Question ID#: 1203.0



The (1) Short-Circuit Current Rating of the equipment, & (2) Available Short-Circuit Current at the equipment site along with the date that calculation was performed are required to be field marked on industrial machinery.

A new subsection has been added requiring industrial machinery to be field-marked with the maximum available short-circuit current. Article 670 already required that the industrial control panel be marked with its short-circuit current rating. It also prohibited industrial machinery from being installed where the available short-circuit current exceeded the short-circuit current rating. So this new marking requirement is intended to make it easier to determine if equipment is properly rated for the short-circuit current available at the machine terminals.

The requirements for the marking of available short-circuit current are like those for marking of service equipment. The marking is a field marking because the available short-circuit current can vary from site to site and even from place to place within a given site. The marking must include the date the short-circuit calculation was performed. The marking must be suitable for the environment so that it will be durable and remain legible in that environment.

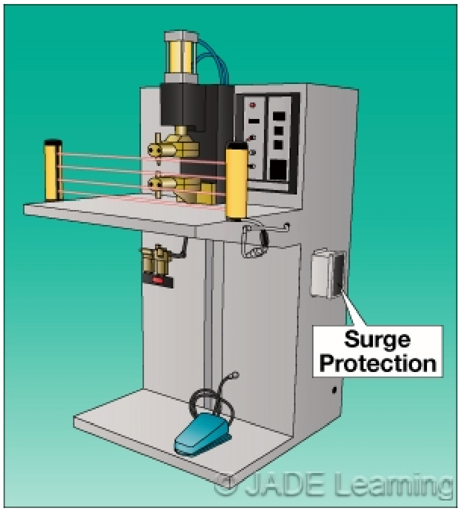
This combination of rules, that the available short-circuit current be calculated and marked, that the equipment be marked with a short-circuit current rating, and that the rating be at least equal to the available short-circuit current, is really just a more specific statement that allows the designer, installer, and inspector to determine that the requirements of Section 110.10 have been met. Those requirements apply to all electrical equipment and installations, but this combination of rules for industrial machinery illustrates how compliance with the rules can be accomplished and demonstrated.

Question 54: A new requirement in Article 670 requires which of the following to be field marked on industrial machinery?

A: The maximum available short-circuit current.
B: The interrupting rating.
C: The current rating.
D: A marking that says the control panel is approved.

Question 55: 670.6 Industrial Machinery. Surge Protection.

Question ID#: 1204.0



Industrial machinery with safety interlocking circuits such as light curtains must have surge protection. Safety interlocking circuits protect personnel who work around the equipment.

Under this new requirement industrial machinery with safety interlock circuits is required to be provided with surge protection. An example of a safety interlock is a light curtain that will shut the machine down if an object like a hand or finger breaks the light curtain.

The type of surge protection is not specified, but it could be a combination of types as described in Article 285 where requirements for surge protective devices (SPDs) are found.

Not all industrial equipment includes safety interlock circuits, but where it does, surge protection is intended to help maintain the safety of personnel who work around the equipment. This is one of a series of requirements for surge protection added in the NEC for systems where reliable operation is critical for safety.

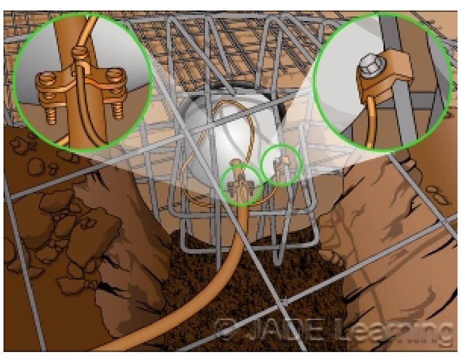
Most of these rules are based simply on the concept that safety and the operation of critical systems should be maintained. However, in this case the requirement is based on specific data. A study commissioned by the Fire Protection Research Foundation provided the results of a survey of facility managers. The survey was about surge damage. It found that surges resulted in damage to safety interlocking systems in 26 percent of the facilities covered by the survey. These failures disabled the safety interlocking systems and exposed workers to increased hazard levels.

Question 55: Under which of the following conditions is surge protection required for industrial machinery?

A: The machinery makes hazardous materials.
B: The machinery is in a hazardous location.
C: The machinery has safety interlock circuits.
D: Surge protection is required for all industrial machinery.

Question 56: 680.7 Swimming Pools, Fountains. Grounding and Bonding Terminals.

Question ID#: 1205.0



Grounding and bonding terminals used in swimming pools must be identified for use in wet and corrosive environments.

Section 680.7, Grounding and Bonding Terminals, is new in the 2017 NEC. The purpose of the section is to make sure that grounding and bonding terminals used for swimming pools, fountains, spas and hot tubs are identified for use in wet and corrosive environments.

680.7 states: "***Grounding and bonding terminals shall be identified for use in wet and corrosive environments. Field-installed grounding and bonding connections in a damp, wet or corrosive environment shall be composed of copper, copper alloy, or stainless steel. They shall be listed for direct burial use."***

Now, only grounding and bonding connectors which are made of copper, copper alloy, or stainless steel will be acceptable in a wet and corrosive environment around a swimming pool, spa or hot tub.

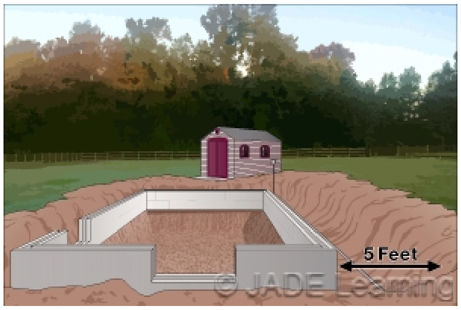
Currently, UL 467 - the standard for Grounding & Bonding of Equipment, doesn't yet have a specific rating for wet & corrosive environments. However, UL Standard 467 does have a rating for Direct Burial (DB) materials. The UL standard requires materials used to manufacture Direct Burial connectors must be resistant to wet and corrosive environments. Direct Burial rated lugs and clamps have proven to be resistant to the corrosive environment around swimming pool equipment. Direct Burial grounding and bonding connections will now be required to be listed for Direct Burial.

Question 56: Which of the following materials would not be permitted for a bonding connection in a wet or corrosive area at a swimming pool?

A: Copper.
B: Steel plated.
C: Stainless steel.
D: Copper alloy.

Question 57: 680.11 Swimming Pools, Fountains. Underground Wiring Location.

Question ID#: 1206.0



Wiring is permitted to be installed within 5 ft. of a swimming pool if it is installed in an approved raceway or cable.

A rewrite of ***Section 680.11 Underground Wiring Locations*** has clarified how underground wiring can be installed under and around a pool. No wiring is permitted under the pool unless the wiring is necessary to supply pool equipment such as lighting installed in the bottom of the pool.

Underground wiring is permitted around the pool if installed in rigid metal conduit (RMC), intermediate metal conduit (IMC), rigid PVC (Polyvinyl Chloride) conduit, reinforced thermosetting resin conduit, or Type MC Cable (Metal-Clad), suitable for the conditions. Also, the Table for minimum cover depths in Article 680 has been deleted because the minimum cover depths for these wiring methods are given in Table 300.5.

The rewrite of Section 680.11 should make it clear that underground wiring is permitted within 5 ft. of the inside wall of the pool. The wording in the 2014 NEC was confusing and unclear.

Example of Wiring Near a Pool

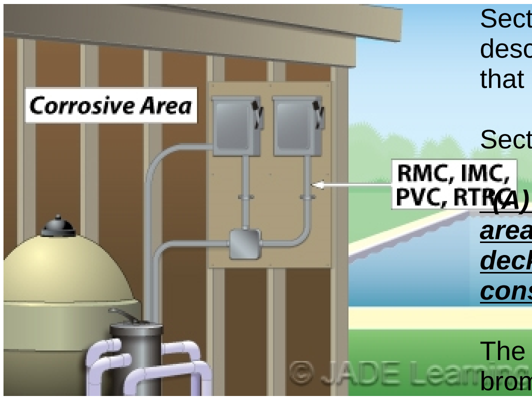
Per the 2017 NEC, an underground feeder to a detached garage can be installed in an area within 5 ft. of the inside pool wall as long as the feeder is installed in one of the conduits or cables listed in this Section. It must adhere to the burial requirements found in Table 300.5.

Question 57: Which of the following wiring methods is NOT permitted for underground pool equipment wiring?

A: Intermediate metal conduit.
B: Rigid polyvinyl chloride conduit.
C: MC Cable suitable for the location.
D: UF Cable.

Question 58: 680.14 Swimming Pools, Fountains. Corrosive Environment.

Question ID#: 1207.0



The wiring methods permitted in corrosive areas around swimming pools are restricted to a limited number of raceways.

Section 680.14 Corrosive Environment is a new Section in the 2017 NEC. It describes the corrosive areas near a swimming pool and lists the wiring methods that are permitted in a corrosive area.

Section 680.14(A) describes locations considered to be a corrosive environment.

"***(A) General. Areas where pool sanitation chemicals are stored, as well as areas with circulation pumps, automatic chlorinators, filters, open areas under decks adjacent to or abutting the pool structure, and similar locations shall be considered to be a corrosive environment."***

The air in these areas is filled with corrosive gasses such as acid, chlorine and bromine which can cause corrosion and eat away at equipment, conduit and wiring.

Section 680.14(B) specifies acceptable wiring methods when installed in a corrosive environment.

"***(B) Wiring Methods. Wiring methods in the areas described in 680.14(A) shall be listed and identified for use in such areas. Rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit, and reinforced thermosetting resin conduit shall be considered to be resistant to the corrosive environment specified in 680.14(A)."***

RMC, IMC, rigid PVC and RTRC are the only wiring methods permitted in corrosive areas where swimming pool chemicals may damage conduit. This includes conduit runs to pool pumps, pool filters, pool heaters, and pool chlorinators.

When wiring methods are not installed in corrosive environments as described in Section 680.14, such as an indoor feeder to a swimming pool panelboard, the wiring methods are not restricted to RMC, IMC, rigid PVC, and RTRC. Other types of cable, conduit and tubing found in Chapter 3 can be used.

Question 58: Which wiring method is permitted for swimming pool wiring located in a corrosive area?

A: Electrical Metallic Tubing: Type EMT.
B: Electrical Nonmetallic Tubing: Type ENT.
C: Rigid Polyvinyl Chloride Conduit: Type PVC.
D: Flexible Metallic Tubing: Type FMT.

Question 59: 680.21(A) Swimming Pools, Fountains. Motors. Wiring Methods.

Question ID#: 1208.0

Different types of wiring methods are permitted in corrosive and noncorrosive areas around swimming pools.

Two types of wiring methods are now permitted for pool pump motors. (1) Wiring that is located in a corrosive environment, as described in new section 680.14, and (2) wiring that is installed in noncorrosive environments.

Wiring installed in noncorrosive environments must comply with the general requirements found in Chapter 3. Wiring installed in a corrosive environment must be installed in rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit or reinforced thermosetting resin conduit. MC cable listed for the location is also permitted.

From section 680.14, corrosive environments are "***areas where pool sanitation chemicals are stored, as well as areas with circulation pumps, automatic chlorinators, filters, open areas under decks adjacent to or abutting the pool structure, and similar locations."*** Any pool equipment, including pool pump motors, must be supplied with a wiring method which complies with the requirements for corrosive areas. Any wiring method used in a corrosive location must contain an insulated copper equipment grounding conductor sized in accordance with Table 250.122, but not smaller than 12 AWG.

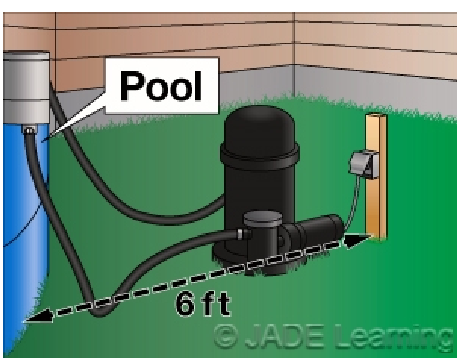
Section 680.21 on Motors has been renumbered and the sections in the 2014 NEC about wiring on or within buildings, and in one-family dwellings have been deleted.

Question 59: Which of the following wiring methods is permitted in a corrosive area of a swimming pool?

A: Electrical Metallic Tubing, Type EMT.
B: Rigid Polyvinyl Chloride, PVC.
C: Electrical Nonmetallic Tubing, Type ENT.
D: Flexible Metallic Tubing, Type FMT.

Question 60: 680.22(A)(2) Swimming Pools, Fountains. Lighting Receptacles, and Equipment. Receptacles. Circulation and Sanitation System, Location.

Question ID#: 1209.0



The distance that a receptacle used for water-pump motors can be located from the pool is restricted.

In the 2014 NEC, single receptacles were required if installed for circulation or pool sanitation system equipment within 6 feet of the inside wall of the pool. Requiring this single receptacle for pool equipment prevented other appliances, like radios and TVs from being connected to a duplex receptacle within 6 ft. of the edge of the pool.

"Receptacles that provide power for water-pump motors or for other loads directly related to the circulation and sanitation system shall be located at least 1.83 m (6 ft) from the inside walls of the pool. These receptacles shall have GFCI protection and be of the grounding type."

The 2017 NEC no longer requires a single receptacle for water- pump motors. Six feet away from the edge of the pool is now considered far enough away from the pool so any appliance plugged into the outlet will not be close enough to the water to fall in. Cord lengths of appliances likely to be used around the pool are typically 3 feet long and would not reach the inside of the pool walls.

The receptacle outlet for the water-pump motors or for other loads related to the circulation and sanitation system must also be of the grounding type and have GFCI protection.

Question 60: What is the minimum distance from the inside wall of a pool required for a receptacle intended for a pool water-pump?

A: 10 feet from the pool wall.
B: 6 feet from the pool wall.
C: 8 feet from the pool wall.
D: 20 feet from the pool wall.

Question 61: 680.22(B)(7) Lighting, Receptacles, and Equipment. Luminaires, Lighting Outlets, and Ceiling-Suspended Fans. Low-Voltage Gas-fired Luminaires, Decorative Fireplaces, Fire Pits, and Similar Equipment.

Question ID#: 1210.0

Low-voltage gas-fired electronic luminaires will be treated like other low-voltage luminaires in the required distance they can be located from the inside edge of the swimming pool or fountain.

Section 680.22(B)(7) is a new section in the 2017 NEC. It was added to clarify the code language of the 2014 NEC and eliminate confusion as to the types of luminaires covered under this section.

Like other low-voltage luminaires covered in 680.22(B)(6), low-voltage gas-fired electronic luminaires will now be permitted to be installed less than 5 ft. from the inside walls of the pool.

Gas luminaire technology increasingly uses low-voltage electronic igniters. Likewise ranges, gas water heaters and gas grilles are using low-voltage electronic igniters instead of always-on pilot lights. The use of low-voltage electronic igniters means the NEC has requirements for these formerly all-gas appliances.

In new section 680.22(B)(7) the transformers or power supplies to low-voltage gas-fired luminaires must meet the same requirements as underwater swimming pool luminaires. Metallic equipment must be bonded to the pool equipotential bonding grid {***code reference for 680.26 (b) (7***)}, just like other pool equipment. Metallic gas piping for the low-voltage gas-fired luminaires, decorative fireplaces, and fire pits must be bonded like other gas appliances according to 250.104(B).

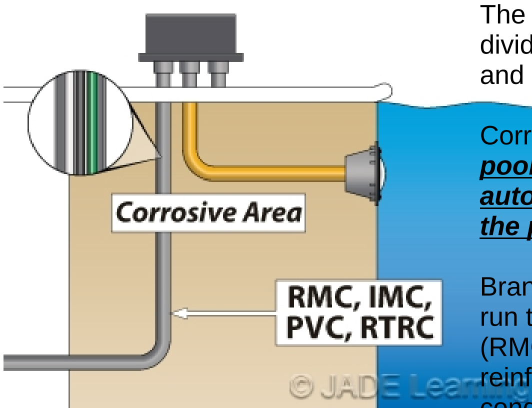
Low-voltage gas-fired luminaires will now be treated like other low-voltage luminaires. The definition of luminaire in Article 100 does not mention the type of light source, power source or fuel source. Just like luminaires with LED's, low-voltage, gas-fired luminaires are still considered luminaires. Their installation around permanently installed swimming pools is spelled out in Section 680.22(B)(7).

Question 61: Low-voltage gas-fired luminaires supplied by a listed transformer are permitted to be installed less than ______ from the inside walls of a pool.

A: 10 feet.
B: 5 feet.
C: 20 feet.
D: 8 feet.

Question 62:   680.23(F)(1) Underwater Luminaires. Branch-Circuit Wiring. Wiring Methods.

Question ID#: 1211.0



Branch circuit wiring in a corrosive area around a swimming pool must be installed in approved raceways and contain a wire-type, insulated copper EGC, for equipment grounding conductor.

The wiring methods for branch-circuit wiring to underwater luminaires are now divided into two separate categories. (1) Branch circuit wiring in corrosive areas, and (2) branch circuit wiring in non-corrosive areas.

Corrosive areas for a swimming pool or spa are defined in 680.14 as: "***Areas where pool sanitation chemicals are stored, as well as areas with circulation pumps, automatic chlorinators, filters, open areas under decks adjacent to or abutting the pool structure, and similar locations."***

Branch-circuit wiring methods on the supply side of enclosures and junction boxes run to underwater luminaires in corrosive areas are limited to rigid metal conduit (RMC), intermediate metal conduit (IMC), rigid polyvinyl chloride conduit (PVC), and reinforced thermosetting resin conduit (RTRC). Liquidtight flexible nonmetallic conduit is also permitted.

All branch circuit wiring installed in a corrosive environment must contain an insulated copper equipment grounding conductor sized in accordance with Table 250.122, but not smaller than 12 AWG.

Where installed in noncorrosive environments around a swimming pool or spa, branch circuit wiring and wiring methods are not restricted like they are in corrosive environments. Any of the general requirements in Chapter 3 of the NEC are permitted.

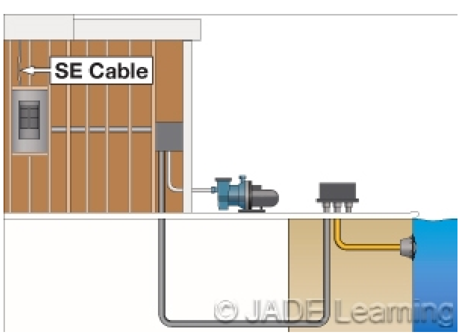
Liquidtight flexible metal conduit is permitted for branch circuit wiring that connects to transformers or power supplies for pool lights. The length cannot exceed 6 ft. for any one length or 10 ft. in total length.

Question 62:   What is the minimum size equipment grounding conductor installed with a branch circuit to an underwater luminaire in a corrosive area?

A: 10 AWG.
B: 6 AWG.
C: 12 AWG.
D: 2 AWG.

Question 63:   680.25 Permanently Installed Pools. Feeders.

Question ID#: 1212.0



If installed outside of the corrosive environment, Feeders which are on the supply side of panelboards which supply pool equipment no longer require an insulated equipment grounding conductor. Any wiring method found in Chapter 3 is acceptable.

The 2014 NEC required feeders on the supply side of panelboards that supplied branch circuits to swimming pools to have an insulated equipment grounding conductor. This was a big problem in dwellings if a homeowner wanted to install a swimming pool and use an existing panelboard to feed pool equipment. If the existing feeder from the service to the panelboard did not have an insulated equipment grounding conductor, the homeowner could not use that panelboard to supply the pool equipment. The homeowner would either have to supply the pool equipment as branch circuits from the service equipment, or install a new feeder to the pool panelboard.

The 2017 NEC has corrected this situation by allowing feeders which are installed in non-corrosive environments, and are on the supply side of panelboards which feed pool equipment, to be wired with any method found in Chapter 3. This means that feeders which are in noncorrosive areas can be installed using cables that do not have an insulated equipment grounding conductor, such as Service Entrance (Type SE) cable.

Feeders that are in corrosive areas, and are on the supply side of panelboards supplying branch circuits for pool equipment, must have an insulated equipment grounding conductor sized in accordance with Table 250.122, but not smaller than 12 AWG. For example, the minimum size of an insulated copper equipment grounding conductor for a 60 amp feeder in a corrosive location would be a No.10 AWG per Table 250.122, for a feeder protected at 100 amps the minimum size copper equipment grounding conductor would be No. 8 AWG, and a No. 6 AWG copper would be required for a feeder protected at 200 amps.

These same types of feeders in corrosive areas can only be installed in rigid metal conduit (RMC), intermediate metal conduit (IMC), rigid polyvinyl chloride conduit (PVC), and reinforced thermosetting resin conduit (RTSC). Liquidtight flexible nonmetallic conduit is also permitted.

Question 63: What is the minimum size equipment grounding conductor to a 100 amp panelboard that is located in a corrosive area and supplies branch circuits to pool equipment?

A: No. 12 AWG.
B: No. 10 AWG.
C: No. 8 AWG.
D: No. 6 AWG.

Question 64: 680.42(C) Spas and Hot Tubs. Outdoor Installations. Interior Wiring to Outdoor Installations.

Question ID#: 1213.0

Branch circuits inside dwellings that supply the disconnecting means for an outdoor spa or hot tub can be installed using Chapter 3 methods, including cables with a bare equipment grounding conductor.

Section 680.42(C) permits any wiring method recognized or permitted by Chapter 3 to be used for the interior portion of circuits for the connection of the disconnecting means and the motor, heating, and control circuits that are part of a self-contained spa or hot tub, or part of a packaged hot or spa equipment.

The wording is much the same as the 2014 NEC, but the 2014 NEC did not mention the disconnecting means. The intent of the change is to make it clear that a Chapter 3 wiring method, such as Type NM cable can be used if routed through the interior of a dwelling or through the interior of another building associated with a dwelling such as pool cabana building. This applies to wiring on both the supply side and load side of the disconnecting means.

For example, wiring from the load side of a disconnect mounted on the exterior wall may be concealed by routing the cable through the wall to a weatherproof junction box on the wall close to a self-contained spa or hot tub. Type NM cable can be used, but only for the portion of the wiring between the disconnect and the junction box. The outside wiring from the junction box to the spa or hot tub equipment would need to be suitable for a wet location.

It should also be noted that this section also applies to packaged spa and hot tub equipment that may not physically part of a spa or hot tub. The packaged equipment is connected to the outdoor spa/hot tub by plumbing. In this case the packaged equipment may not be physically located at the tub. Type NM cable or other Chapter 3 wiring method is permitted for any portion of the wiring installed in the interior of the dwelling or within the interior of a building associated with the dwelling. This applies only to wiring for connection of the disconnection means, motor, heating, and control loads that are part of the spa or hot tub equipment.

The 2017 change does not apply to wiring connected to underwater luminaires. Wiring for underwater luminaires must comply with the requirements in 680.23 or 680.33.

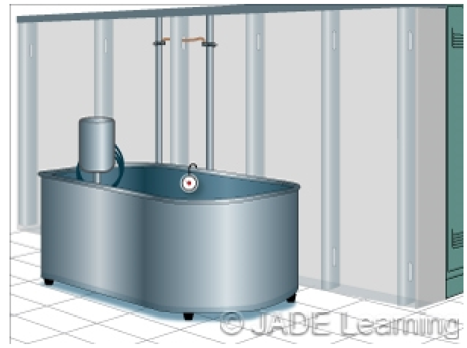
Question 64: The general wiring requirements found in Chapter 3 may NOT be used for the connection to a motor disconnecting means and the motor, heating, and control loads for which of the following?

A: A residential self-contained spa or hot tub.
B: A residential packaged spa.
C: A residential hot tub equipment assembly.
D: A residential hot tub built into a permanently installed swimming pool.

Question 65: 680.74 Hydromassage Bathtubs. Bonding.

Question ID#: 1214.0

Equipotential bonding is required for hydromassage pools and hot tubs. An equipotential bonding plane can be established for the hydromassage bath tub by bonding together all of the items listed in Section 680.74(A). A solid copper bonding jumper, insulated, covered, or bare, not smaller than 8 AWG is required to bond the various conductive parts together.



Metal-sheathed cables, metal raceways, and metal piping within 5 ft. of the inside walls of the tub that are not separated from the tub by a permanent barrier must be bonded together.

The 2014 NEC said the metal piping system and any grounded parts of the hydromassage tub in contact with the circulating water had to be bonded together.

The 2017 NEC has similar requirements, and adds some specific types of equipment and raceways that must be bonded together. The additions include:

- Metal-sheathed cables, metal raceways, and metal piping within 5 ft. of the inside walls of the tub that are not separated from the tub by a permanent barrier.
- All exposed metal surfaces that are within 5 ft. of the inside walls of the tub and not separated from the tub area by a permanent barrier.
- Electrical devices and controls that are not associated with the hydromassage tub and that are located within 5 ft. from such units.

A new exception has been written that would exempt small conductive surfaces, like towel bars and mirror frames, which are not likely to become energized from the bonding requirements.

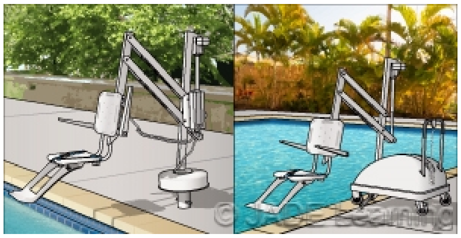
A second exception excludes double-insulated motors and blowers from the bonding requirements. However, a bonding jumper long enough to terminate on a replacement non-double-insulated pump or blower motor must be provided. The bonding jumper must be terminated to the equipment grounding conductor of the branch circuit of the motor when a double-insulated circulating pump or blower motor is used.

Question 65: What is the minimum size solid copper conductor permitted for use when bonding a non-double-insulated hydromassage tub blower motor?

A: No. 12 AWG.
B: No. 8 AWG.
C: No. 10 AWG.
D: No. 6 AWG.

Question 66: 680 Part VIII Electrically Powered Pool Lifts. Equipment Approval and Protection.

Question ID#: 1215.0



<u>Lifts that are operated above the low voltage contact limit must be listed, labeled and identified for swimming pool and spa use. Low voltage and battery powered lifts are not required to be listed or labeled under the conditions specified in the exceptions to 680.81.</u>

Article 680 Part VIII, Electrically Powered Pool Lifts is new for the 2017 NEC. An Electrically Powered Pool Lift is a new term in the NEC and defined as "***<u>An electrically powered lift that provides accessibility to and from a pool or spa for people with disabilities."</u>***

Section 680.82 requires lifts that are connected to premises wiring and operate above the low voltage contact limit (defined in 680.2) to be provided with GFCI protection for personnel.

Electrically powered pool lifts must be listed, labeled, and identified for swimming pool and spa use, but there are three exceptions to this, provided in section 680.81.

Lifts that operate at or below the low-voltage contact limit are not required to be listed or labeled if supplied by a listed transformer or power supply that complies with 680.23(A)(2). The low-voltage contact limit is 15 volts for sinusoidal AC and 30 volts for continuous DC.

Battery-powered lifts operating at or below the low voltage contact limit are not required to be listed or labeled if the battery is removed for charging at another location.

Solar-operated and solar-recharged lifts are not required to be listed or labeled if the solar panel is attached to the lift and the battery is rated 24 volts or less.

Section 680.83 requires metal fittings and fixed metal parts of electrically powered pool lifts to be bonded to the equipotential bonding plane required for permanently installed pools in accordance with 680.26(B)(5) and (B)(7).

Question 66: Which of the following electrically powered pool lifts must be listed and labeled.

A: A 24 VDC battery powered lift where the battery is charged off site.
B: A lift powered by a listed power supply where the DC voltage is 30 VDC.
C: A lift operating at 60 volts DC and supplied by a listed transformer.
D: A lift powered by a listed power supply and operating at 24 VDC.

Question 67: 690.1 Solar Photovoltaic (PV) Systems. Scope.

Question ID#: 1216.0

Article 690 covers small scale photovoltaic (PV) installations and Article 691 covers large scale PV installations of 5000 kW and larger.

The Scope of Article 690, in section 690.1, has not changed except for the addition of the following words ***"...other than those covered by Article 691"***, and an informational note: ***Article 691 covers the installation of large-scale PV electric supply stations.*** This implies Article 690 only applies to small-scale PV installations but there has been no added definition to clarify what constitutes small-scale. Article 691, Large-Scale Photovoltaic (PV) Electric Supply Stations, covers PV installations that start at 5,000kW. So Article 690, Solar Photovoltaic (PV) Systems, must cover PV installations smaller than 5,000kW.

There have been major changes to the diagram section by revising some existing diagrams and adding new diagrams. New terminology and phrasing is used with the intent to clarify optional equipment, the location of equipment in a PV system, and more accurately represent the correct nomenclature of PV systems. The diagrams have been modified for consistency with the revisions in Article 690 and reflect the use of new technology. The new diagrams are more complete and use block symbols to simplify identification and location of equipment. In Figure 690.1 (a), optional DC-DC converters have been added and PV source circuits are more easily identified. The notes have also been revised.

In Figure 690.1(b), PV system disconnects are indicated as a shaded block. The location of the required PV system disconnect is shown in each PV type of system in Figure 690.1(B). Note (2) says, ***The PV system disconnect in these diagrams separates the PV system from all other systems.*** Note (3) says, ***Not all disconnecting means required by Article 690, Part III are shown.*** None of the Figures in section 690.1 in the 2014 NEC included the location of a PV system disconnect.

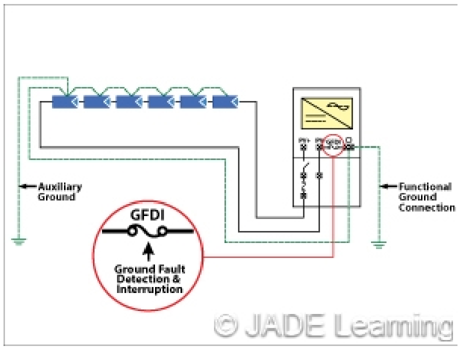
There are also two new diagrams for a DC coupled system and an AC coupled system. In these newly added diagrams the multimode inverter is also clearly indicated. The definition of a multimode inverter was introduced in the 2014 NEC cycle as ***"Equipment having the capabilities of both the utility-interactive inverter and the stand-alone inverter."*** As the diagram shows, a multimode inverter has bi-directional capability which can provide a DC charge to a battery bank using AC from the grid, while also producing AC output from the battery bank to feed into the grid or emergency back-up circuits.

Question 67: Which of the following solar photovoltaic (PV) systems is covered in the scope of Article 690?

A: A 10,000 kW system.
B: A 4,000 kW system.
C: A 6,000 kW system.
D: A 8,000 kW system.

Question 68: 690.2 Solar Photovoltaic (PV) Systems. Definitions.

Question ID#: 1217.0



Functionally grounded PV systems are connected to ground through a fuse, circuit breaker, resistance device, another grounded circuit or through a ground-fault protection system.

This change adds a new term and its definition. The use of the new term ***Functional Grounded PV System*** is intended to clarify the difference between solidly grounded systems and those grounded by other means.

A solidly grounded system is defined as a system that is connected to ground without inserting a resistor or impedance device.

Functional Grounded systems may be connected to earth through a fuse, circuit breaker, a resistance device, some other grounded circuit, or by electronic means that is part of a listed ground-fault protection system rather than by direct connection to ground. A Functional Grounded PV System is defined as one that has an electrical reference to ground that is not solidly grounded. The term includes systems grounded through an impedance or resistance, but also includes systems grounded by other means.

An important difference between a functional grounded PV system and one that is solidly grounded is that a grounded conductor in a functional grounded PV system may have a higher voltage to ground under a fault condition because the grounded conductor may be disconnected from ground reference as a result of the fault. In a solidly grounded system the grounded conductor remains at or near ground potential or ground reference during and after a fault because it remains solidly connected to ground.

Since most recently installed PV systems have been functional grounded systems and not solidly grounded systems, the addition of the term should not have a great effect on current practices. However, the new term is used in several places in Article 690 and a new definition of functional grounded PV systems will be useful to distinguish between grounding methods and requirements.

Question 68: A Functionally Grounded PV System is a one that has an electrical reference to ground that is:

A: Solidly grounded.
B: Not grounded.
C: Not solidly grounded.
D: Ungrounded.

Question 69: 690.7 Solar Photovoltaic (PV) Systems. Maximum Voltage.

Question ID#: 1218.0

Maximum voltage 600 volts

Maximum voltage 1000 volts

Maximum voltages for PV systems are 600 volts for one- and two-family dwellings and 1000 volts for other systems in or on buildings.

Section 690.7 was revised to simplify the section.Â It defines the maximum voltage of a circuit, establishes the maximum voltages and then provides three methods for determining the maximum voltage.Â Maximum voltages are 600 volts for one- and two-family dwellings and 1000 volts for other systems in or on buildings.Â This maximum voltage is used to determine the required voltage rating for conductors, disconnects, and other equipment connected to the system.

The three methods of determining maximum voltage are based on the type of system: (A) Photovoltaic Source and Output Circuits, (B) DC-to-DC Converter Source and Output Circuits, and (C) Bipolar Source and Output Circuits.

The maximum voltage for the first type of system, Photovoltaic Source and Output Circuits, can be determined by one of three ways. Any one of the 3 following methods applicable to the system is permitted to be used. (1)Based on the instructions in the listing or labeling of the module. (2) The sum of the PV module-rated open-circuit voltages of the series-connected modules. Correction factors from Table 690.7 (A) must be applied.Â (3) Under engineering supervision for systems rated 100 kW or larger.Â

The maximum voltage for the second type of system, DC-to-DC Converter Source and Output Circuits, was added because this type of system did not fit into the method for Photovoltaic Source and Output Circuits and was not specifically addressed in the 2014 edition of the Code.

The maximum voltage for the third type of system, Bipolar Source and Output circuits, was changed to recognize the use of functional grounded systems.Â Systems have been solidly grounded to prevent overvoltage, but functional grounded systems have been shown to work as well at controlling overvoltages while allowing for effective ground fault detection that was not possible with some solidly grounded designs. Since the functional grounded systems have been shown to be safer, the new requirements recognize only that type of bipolar arrangement.

Question 69: Which one of the following statements about calculating maximum dc voltage of Photovoltaic Source and Output Circuits is NOT correct?

A: Calculations can be based on the sum of the PV module-rated open-circuit voltage of the series- connected modules corrected for ambient temperature in accordance with the listing and labeling instructions of the module.
B: Calculations for crystalline and multicrystalline modules can be based on the sum of the PV-module-rated open-circuit voltage of series connected modules and the ambient temperature correction factors in Table 690.7(A).
C: For PV systems of 100 kW or more, calculations can be based on an industry standard method and a documented and stamped PV system design by a licensed professional.
D: For PV systems rated 50 kW and less there is no requirement to calculate the maximum PV system output circuit voltage.

Question 70: 690.11 Solar Photovoltaic (PV) Systems. Arc-Fault Circuit Protection (Direct Current).

Question ID#: 1219.0

A new exception permits PV output circuits and dc-dc converter output circuits that are not installed on or in buildings to omit arc-fault protection.

Section 690.11 has been revised to clarify requirements for arc-fault circuit protection of direct current PV systems operating at 80 volts dc or greater between any two conductors. The arc-fault protection system must be capable of detecting and interrupting arc-faults that result from failure in the intended continuity of a conductor, connection, module, or other circuit component in the dc circuits. An exception to the arc-fault protection requirement has been added that applies under certain conditions.

The new exception added to Section 690.11 states "***For PV systems not installed on or in buildings, PV output circuits and dc-dc converter output circuits that are direct buried, installed in metallic raceways, or installed in enclosed metallic cable trays are permitted without arc-fault circuit protection. Detached structures whose sole purpose is to house PV system equipment shall not be considered buildings according to this exception."*** This new exception permits ground-mounted PV systems or PV systems installed on the roof of equipment structures such as a shed to be installed without arc-fault detection.

Section 690.11 has been revised to remove the words ***'Photovoltaic systems with dc source circuits, dc output circuits, or both,..*** " and changed to "***PV systems*** o ***perating at 80 volts or greater between any two conductors..."*** which implies protection for both conductors in a bipolar PV system. Also, the list of (3) product specifications and requirements for DC arc-fault detection has been removed. Product specifications, testing, listing and approval for use is performed by Nationally Recognized Third Party Testing Laboratories (NRTTL's) such as UL, Intertek, CSA, etc. It is not within the scope of the NEC to specify product requirements. A new Informational Note was added to refer the reader to Annex A which includes a reference for the Photovoltaic DC Arc-Fault Circuit Protection product standard.

Question 70: Which of the following residential roof-mounted PV systems are required to have DC arc-fault detection installed?

A: Systems operating at 24 volts DC.
B: Systems operating at 48 volts DC.
C: Systems operating at 72 volts DC.
D: Systems operating at 85 volts DC.

Question 71: 690.12 Solar Photovoltaic (PV) Systems. Rapid Shutdown of PV Systems on Buildings.

Question ID#: 1220.0

The rapid shutdown device must clearly indicate whether the device has initiated the rapid shutdown function of the PV system. "Off" means the device has been activated to shutdown the PV system.

PV system circuits installed on or in buildings must include a rapid shutdown function to reduce shock hazard for emergency responders.

A new exception permits ground mounted PV system circuits that enter buildings, of which the sole purpose is to house PV system equipment, to omit rapid shutdown equipment. This exception refers to equipment shelters or sheds.

The PV array boundary is an area 1 ft. from the array in all directions.

PV conductors outside the array boundary or more than 3 ft. from the point of entry inside a building are limited to not more than 30 volts within 30 seconds of rapid shutdown.

PV conductors inside the array boundary or not more than 3 ft. from the point of penetration of the surface of the building are limited to not more than 80 volts within 30 seconds of rapid shutdown.

The initiation device initiates the rapid shutdown function of the PV system. When the device is "off" it has initiated the rapid shutdown function.

The rapid shutdown initiation device consists of at least one of the following: (1) Service disconnecting means (2) PV disconnecting means (3) Readily accessible switch that plainly indicates whether it is in the "off" or "on" position.

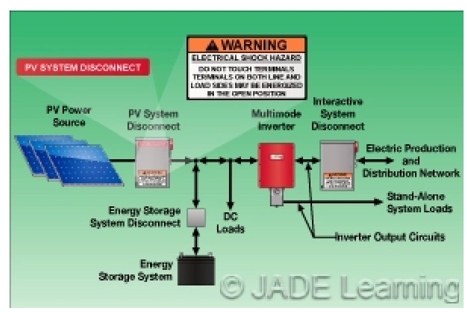
Question 71: What is the main purpose of rapid shutdown on PV systems?

A: To eliminate static electricity.
B: To reduce the shock hazard for emergency responders.
C: To turn exterior lights off quickly.
D: Data acquisition purposes.

Question 72: 690.13 Solar Photovoltaic (PV) Systems. Photovoltaic System Disconnecting Means.

Question ID#: 1221.0

Section 690.13 no longer requires PV system "disconnecting means" to be located closest to the conductor's point of entry. This was done primarily so disconnects can be installed on PV array tracking structures. Section 690.13 now states: "***The PV system disconnecting means shall be installed at a readily accessible location.***"



The PV system disconnect must be installed at a readily accessible location and be marked with a warning sign about the electrical shock hazard.

Readily Accessible according to Article 100 of the NEC means easy to reach without having to climb over or under anything; without having to move obstacles; without having to use a portable ladder (but permanent ladders are OK) and without resorting to using any tools - ***except keys***. Keys are not considered a tool according to the definition and they ***are allowed*** for readily accessible equipment.

Other Changes to 690.13 for the 2017 Code Cycle

690.13(B). 690.13(B) Marking says each PV system disconnecting means must be permanently marked ***PV SYSTEM DISCONNECT*** and clearly indicate whether it is in the open or closed (meaning on or off) position. The disconnect must have a warning sign stating:

WARNING

ELECTRIC SHOCK HAZARD

TERMINALS ON THE LINE AND LOAD SIDES MAY BE

ENERGIZED IN THE OPEN POSITION

690.13(E). ***690.13 (E)*** the title and topic have been changed from "Grouping" to "Ratings" and states "***The PV system disconnecting means shall have ratings*** (in amps) ***sufficient for the maximum circuit current; available short-circuit current; and voltage that is available at the terminals of the PV system disconnect."***

690.13(F). ***690.13(F) Type of Disconnect*** is new and provides details for the types of approved disconnects for PV systems. The disconnecting means must be externally operable and marked ***suitable for use in a PV system*** or ***suitable for back feed operation***.

These requirements for disconnects for PV systems have also been added:

1) "Simultaneous Disconnection" which is not a new requirement, is now more clearly stated in this Section.

2) "Devices Marked "Line" and "Load." Devices marked with "line" and "load" shall not be permitted for back feed or reverse current."

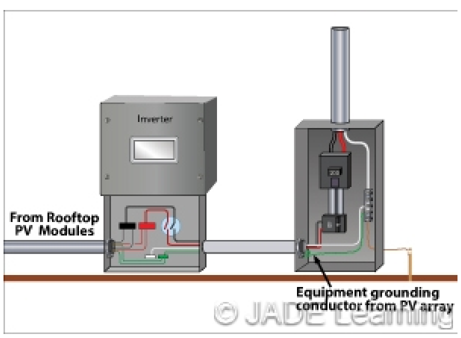
3) "DC-Rated Enclosed Switches, Open-Type Switches, and Low-Voltage Power Circuit Breakers." These devices are declared as permitted for use in back feed operation.

Question 72: Which one of the following locations is NOT acceptable for mounting PV system disconnecting means?

A: On a roof accessible by a portable ladder next to the array.
B: 4 feet above grade on the PV tracking structure.
C: Outside next to the electrical service.
D: On the exterior of a house 48 inches from grade.

Question 73: 690.47 Solar Photovoltaic (PV) Systems. Grounding Electrode System.

Question ID#: 1222.0



Functional grounded PV systems can make a connection to ground using the equipment grounding conductor for the output of the PV system instead of connecting directly to a grounding electrode.

This section was completely rewritten and simplified.Â The revised section is divided into two parts, Section 690.47(A) that covers when a grounding electrode system is required, and Section 690.47(B) that permits the use of additional electrodes directly connected to an array frame or structure and refers to Article 250 to determine if an array frame or structure qualifies as a grounding electrode.Â

The previous version of this section included five slightly different scenarios for which a grounding electrode system would be required.Â Those requirements have been simplified to a single rule that says a grounding electrode is required for any building or structure used to support a PV array.Â The rule also addresses the connection of PV array equipment grounding conductors to the grounding electrode system including rules for both solidly grounded systems and systems that are not solidly grounded.Â Generally, all equipment grounding conductors will be required to be connected to the grounding electrode system through the ordinary methods of equipment grounding in Article 250.

An informational note explains that most systems installed in recent years have been functional grounded systems, not solidly grounded systems.Â Such systems are permitted to make a connection to ground for grounded conductors using the equipment grounding conductor for the output of the PV system and using connections to associated grounded distribution equipment rather than by connecting directly to any electrode with a grounding electrode conductor.Â This is a significant change in the way grounding of PV systems is understood to be done and is an important reason for the addition of functional grounded systems in

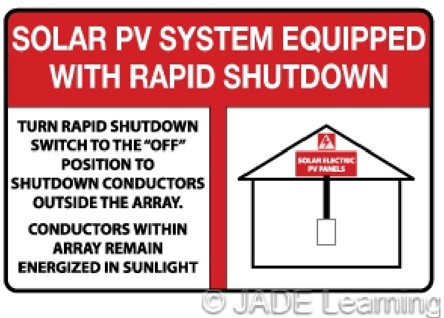
2017.Â It has no effect on the equipment grounding connections between arrays or structures which still also require a direct or indirect connection to a grounding electrode.Â However, the recognition that many systems are grounded through the equipment grounding conductors for the modules rather than through grounding electrode conductors means that grounding electrode conductors are not required for grounding of such systems.

Question 73: When is a grounding electrode required for PV Systems?

A: When any building or structure is supplied by a PV system.
B: When any building or structure supports a PV array.
C: When an equipment grounding conductor is not present.
D: When additional electrodes are connected directly to a frame or structure.

Question 74: 690.56 Solar Photovoltaic (PV) Systems. Identification of Power Sources.

Question ID#: 1223.0



690.56(C)(1) provides 2 different color schemes depending on the type or rapid shutdown system. White letters on a red background are used if the conductors inside the array remain energized after the rapid shutdown switch is operated. Black letters on a yellow background are used where conductors inside and outside the array are shut down.

The color schemes for PV system labels described in 690.56(C)(1), (C)(2), and (C)(3) can be confusing.

There are two color schemes for the rapid shutdown label described in 690.56(C)(1) that are installed at the service disconnecting means to which the PV systems connect, additional information may be required on the label by (C)(2) and an additional label is required by (C)(3) at or near the rapid shutdown switch.

The labels in 690.56(C)(1) identify the 2 different types of rapid shutdown. A different color scheme is used for each. This label is to be placed on or within 3 ft. of the service disconnecting means to which the PV system(s) connect. The label must also indicate the location of the actual rapid shut down switch(es) unless those switch(es) are at the same location as the service disconnecting means.

690.56(C)(1) Color Scheme No.1: For PV systems that shut down both the array and the conductors exiting the array, the title SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN shall be in capital letters in BLACK on a YELLOW background. The remaining letters shall be in black on a white background

690.56(C)(1) Color Scheme No. 2: For PV systems that shutdown only the conductors exiting the array, the title SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN shall be in capitalized letters in WHITE on a RED background. The remaining characters are black on a white background. The color red is used to alert the fire department that conductors within the PV array remain energized.

The label(s) required by 690.56(C)(1) are located at the service disconnecting means. The label must also indicate the location of the actual rapid shutdown switch itself (unless it is at the same location as the service disconnect). This allows the fire department to locate the switch and initiate the rapid shutdown.

It should also be noted that there may be PV systems with rapid shutdown of either or both types on the same building with PV systems that are not equipped with rapid shut down.

690.56(C)(2) For buildings with more than one shutdown type, 690.56(C)(2) requires a detailed plan view diagram of the roof showing each different PV system. There must be a dotted line around any areas that remain energized after the rapid shutdown is accomplished.

690.56(C)(3) Rapid Shutdown Switch Label Color Scheme No. 3. (C)(3) requires a label on or within 3 ft. of the rapid shutdown switch. The wording shall state RAPID SHUTDOWN SWITCH FOR PV SYSTEM The label shall be REFLECTIVE with all letters capitalized in WHITE on a RED background. Note that this label is required to be reflective to make it easier for emergency responders to locate. No colors other than white characters on a red background are specified.

In summary the labels described in (C)(1) and (C)(2) at the service disconnecting means inform the fire department of the type of PV system(s) that are present on the building. The reflective label required by (C)(3) on or within 3 ft. of the rapid shutdown switch allows the fire department or other emergency responders to locate the switch and initiate the rapid shutdown.

Question 74: What colors are used for the words "SOLAR PV SYSTEM IS EQUIPPED WITH RAPID SHUTDOWN" for rapid shutdown systems that shut down the array and conductors exiting the array?

A: Black letters, yellow background.
B: Black letters, white background.
C: White letters, red background.
D: Red letters, white background.

Question 75: Article 691 Largeâ€“Scale Photovoltaic (PV) Electric Power Production Facility.

Question ID#: 1224.0

New Article 691 covers privately owned large scale PV systems rated 5000kW and larger.

Article 691 is new in the 2017 National Electrical Code. It was created to address the design and installation differences between large scale (5000 kW and larger) PV systems, which are typically done at the utility level, and residential and small commercial systems. Section 691.1 Scope says, "***This article covers the installation of large-scale PV electric supply stations with a generating capacity of no less than 5000 kW, and not under exclusive utility control."***

There are two informational notes with the first note further stating the intent and scope of this new article: Informational Note No. 1, "***Facilities covered by this article have specific design and safety features unique to large-scale PV facilities and are operated for the sole purpose of providing electric supply to a system operated by a regulated utility for the transfer of electric energy."*** It is important to note this article provides rules for installations for large PV systems (commonly referred to as "utility scale") designed specifically to tie into utility infrastructure. A third party has designed and installed the system, and the energy output of the system will be sold to the utility, but the PV system is not under the utility's control. PV systems that are installed and controlled by utilities or are on utility-owned property are not regulated or covered in the NEC.

Informational note No. 2 refers to Section 90.2(B)(5) which defines the scope of the NEC and also specifies what is not covered. Specifically, installations under exclusive control of the electric utility. It also contains a reference to ANSI/IEEE C2-2012, the National Electrical Safety Code, for additional information on electric supply stations relevant to PV systems not covered by Article 690 or 691.

Article 691 also includes:

- A new definition of Electric Supply Stations: ***Locations containing the generating stations and substations, including their associated generator, storage battery, transformer, and switchgear areas.***
- A requirement for equipment in large-scale photovoltaic (PV) electric supply stations to be maintained and operated only by qualified personnel.
- A requirement for equipment approval by listing and labeling, field labeling, or by engineering review.
- A requirement for the construction of the electric supply station to conform to the electrical engineered design, and that documentation be provided to the AHJ upon request.

Question 75: Which of the following statements about Large-Scale Photovoltaic (PV) Electric Supply Stations, as described in Article 691 is true?

A: They are under the exclusive control of a utility.
B: The installation requirements of the supply station are governed by the National Electrical Safety Code (NESC) for utilities.
C: They are not under the exclusive control of the utility.
D: They must be installed on utility-owned property.

Question 76: 695.14(F) Fire Pumps. Control Wiring. Generator Control Wiring Methods.

Question ID#: 1225.0

Control circuits between a fire pump and the generator transfer switch must be continually monitored so if there is a problem both an audible and visual alarm is initiated.

The control circuits between a fire pump power transfer switch and the standby generator for the fire pump are critical to the operation of the fire pump. A new requirement has been added to ensure that a problem with the generator start circuit will not go undetected.

The integrity of the generator control wiring shall be continuously monitored. Loss of integrity of the remote start circuit(s) shall initiate visual and audible annunciation of generator malfunction at the generator local and remote annunciator(s) and start the generator(s).

Visual and audible signals at the generator and at remote annunciators will alert maintenance personnel that there is a problem. The loss of control circuit integrity will also cause the generator to start and run until the control circuits are repaired. Starting the generator ensures emergency power is available if needed.

Continuous monitoring of the generator control circuits is not a substitute for physical protection of the conductors. Control circuits routed through the building must be protected by one of the following methods:

1) ***Be encased in a minimum 2 in. of concrete.***

2) ***Be protected by a fire-rated assembly listed to achieve a minimum fire rating of 2 hours and dedicated to the fire pump circuits***.

3) ***Be a listed electrical circuit protective system with a minimum 2-hour rating.***

The generator control circuit conductors between the standby generator and the fire pump transfer switch must be kept entirely separate from all other wiring.

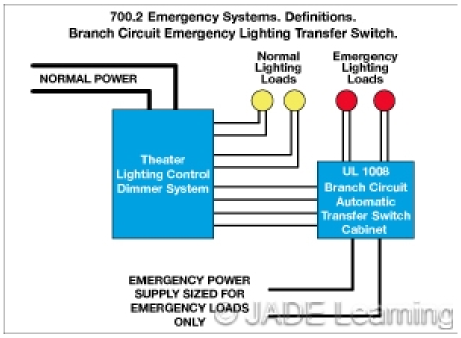
Question 76: A break in a remote start circuit conductor between the generator and the fire pump will result in which one of the following?

A: Activation of the building fire alarm.
B: The fire pump will start and run.
C: The generator will start and run.
D: A visual and audible signal will be sent to the local fire department.

Chapter 7

Question 77: 700.2 Emergency Systems. Definitions.

Question ID#: 1226.0



A branch circuit emergency lighting transfer switch transfers only lighting loads from the normal supply to the emergency supply.

Chapter 7 covers Special Conditions, and Article 700 deals particularly with Emergency Systems. There are a number of definitions of terms in 700.2 that are specific to Article 700. One of the most important is the existing definition of Emergency Systems. Only those systems that are "***legally required and classed as emergency by municipal, state, federal, or other codes,***" fall within the scope of Article 700. Emergency systems are typically installed to provide illumination for exit paths and to prevent panic in case the normal power fails subject to occupancy by a large number of persons such as hotels, theaters, hospitals and similar facilities.

Two new definitions have been added in 700.2. A definition of ***Directly Controlled Luminaire*** and a definition for a ***Branch Circuit Emergency Lighting Transfer Switch.*** The increasing use of dimmer and relay systems with automatic load control relays to control emergency lighting branch circuits in theatres and similar occupancies created a need for this new type of transfer switch.

Branch Circuit Emergency Lighting Transfer Switch. A device connected on the load side of a branch circuit overcurrent protective device that transfers only emergency lighting loads from the normal supply to an emergency supply.

A ***Branch Circuit Emergency Lighting Transfer Switch*** is evaluated to meet UL Standard 1008 as an automatic emergency transfer switch. The rating of the branch circuit connected to a branch circuit emergency lighting transfer switch is limited to no more than 20 amperes by section 700.25

A branch circuit emergency lighting transfer switch is exempt from the mechanically held requirements of 700.5(C).

Relay and dimming systems using automatic load control relays listed for use as emergency lighting equipment in accordance with UL 924 have sometimes been used as a substitute for listed emergency transfer switches. These products are not evaluated to meet the UL 1008 standard for transfer switches. They are designed only as a control device to by-pass normal dimming functions in the event of a power failure to ensure that the emergency lighting is fully illuminated. This means a separate listed emergency transfer switch has to be installed ahead of the lighting control panel in order to comply with the NEC.

A ***Branch Circuit Emergency Lighting Transfer Switch*** on the load side of a dimmer lighting control panel allows emergency lighting loads to be automatically transferred from a normal power branch circuit to an emergency system branch circuit, without the need to install a full size transfer switch ahead of the lighting control panel. Dimming functions and local control are bypassed if normal power is interrupted and the emergency lighting is fully illuminated until normal power is restored.

The technology to selectively control emergency lighting branch circuits ensures that emergency illumination will be available when needed, while allowing greater flexibility in the design of lighting systems.

A ***directly controlled luminaire*** includes an integral dimming or switching function that has a control input that will cause the luminaire to be fully illuminated upon loss of normal power. The term directly controlled luminaires was used in the 2014 NEC, but no definition was provided.

As LED lighting technology continues to expand, the use of both branch circuit emergency lighting transfer switches and directly controlled luminaires will become more common.

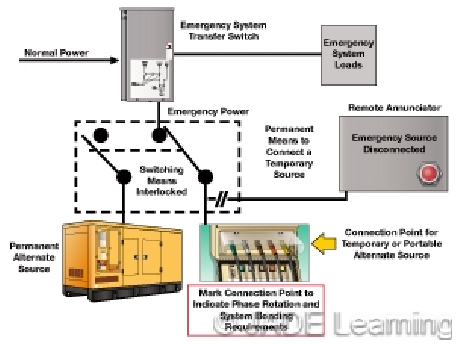
Question 77: Which of the following is acceptable as an emergency transfer switch for a 15 amp rated emergency lighting branch circuit?

A: An automatic load control relay listed to comply with UL 924.
B: A relay and dimming system.
C: A listed Branch Circuit Emergency Lighting Transfer Switch.
D: A listed manual transfer switch.

Question 78: 700.3(F) Emergency Systems. Tests and Maintenance. Temporary Source of Power for Maintenance or Repair of the Alternative Source of Power.

Question ID#: 1227.0

A permanent switching means is now required to be installed to allow connection of a temporary source of power when the permanently installed alternate power source for an emergency system is disabled for maintenance or repair.



A permanently installed switching means is now required to switch to a temporary alternate power source when the normal alternate power source is disabled for maintenance or repair.

An emergency system is a legally required system intended to, ***"supply, distribute, and control power and illumination essential for safety to human life,"*** (700.2). Emergency systems are typically installed in places or assembly, high rise buildings, hotels, health care facilities, and similar occupancies to provide illumination of the means of egress and prevent panic if the normal power source fails. In most cases these buildings cannot be legally occupied without a functioning emergency system. For example, a basketball game may be attended by thousands of people. In the event of normal power failure the emergency system must function to allow people to exit the building. The same is true for a high-rise office building or a hospital. The emergency system must always be ready to function. However, emergency systems, like all other electrical systems, will require maintenance from time to time.

Alternate power sources, such as a generator powered by a diesel engine, may require both routine scheduled maintenance and non-scheduled major repairs. If the emergency system relies on a single alternate power source, a permanent switching means is now required to provide a way to connect a portable generator or other temporary power source to the emergency system until the maintenance or repair on the permanent alternate power source is completed. A portable or temporary alternate source of power "***shall be available for the duration of the maintenance or repair."*** (700.3(F)).

Manual switching is permitted to accomplish the transfer from the permanent alternate source to the temporary alternate power source, but the switching means used must comply with all of the following:

1) Connection to the portable or temporary alternate power source shall not require modification of the permanent system wiring.

2) Transfer of power between the normal power source and the emergency power source shall be in accordance with 700.12.

3) The connection point for the portable or temporary alternate source shall be marked with phase rotation and system bonding requirements.

4) Mechanical or electrical interlocking shall prevent inadvertent interconnection of power sources.

5) The switching means shall include a contact point that shall annunciate at a location remote from the generator or at another facility monitoring system to indicate that the permanent emergency source is disconnected from the emergency system. (2017 NEC 700.3(F)).

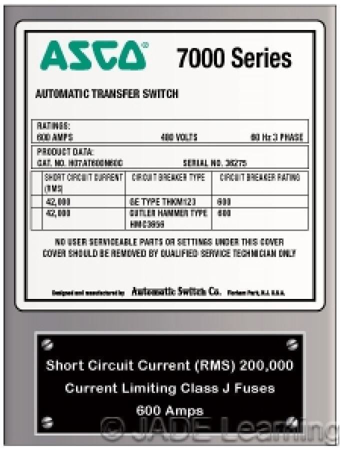
The new requirement for a permanent switching means will ensure that a temporary power source can be installed whenever an emergency generator or other emergency power source is disabled for maintenance or repair.

Question 78: What is the new requirement for a building that requires an emergency system?

A: Two alternate power sources are required to be onsite at all times.
B: Emergency generators connected in parallel must be onsite at all times.
C: A permanent switching means is required onsite to connect a second alternate emergency power source.
D: The normal alternate emergency power source must be tested every week.

Question 79: 700.5(E) Emergency Systems. Transfer Equipment. Documentation.

Question ID#: 1228.0



<u>The short-circuit current rating of the emergency transfer switch must be marked on the transfer switch. The calculated short-circuit rating is based on the specific overcurrent device protecting the transfer switch.</u>

Transfer equipment for emergency systems must now be field marked to indicate the short-circuit current rating of the transfer switch equipment based on "***<u>the specific overcurrent protective device type and settings protecting the transfer equipment."</u>***

In the event of a short-circuit, electrical equipment must be able to carry the short-circuit current until a fuse or circuit breaker opens and clears the fault. The type of fuse or circuit breaker that is used to protect the transfer switch has a big effect on the short-circuit rating of the transfer switch. The faster the overcurrent device opens, the higher the short-circuit current rating. Since the manufacturer of the transfer switch equipment does not know the type of overcurrent protection that will be provided on site, the equipment must be marked with short circuit rating based on the type and rating of the fuse or circuit breaker installed on the line side of the transfer equipment.

An additional concern for transfer equipment is the possibility that the transfer switch will detect a loss of power and close under fault conditions. Manufacturers typically refer to short circuit current ratings for transfer equipment as the Short-Circuit Withstand and Closing Rating or WCR of the equipment. The short-circuit current rating of transfer equipment must not be less than the short-circuit current available from either the normal source or the alternate power source.

Manufacturers may specify several approved Short-Circuit Withstand and Closing Ratings for a transfer switch, depending on the type of overcurrent protective device used to protect the switch. For example, current limiting fuses open much faster in the event of a short circuit than standard circuit breakers. A transfer switch will usually have a higher Short-Circuit WCR rating when protected by fuses than when protected by a standard circuit breaker.

Some transfer switches may also be evaluated for use with a specific manufacturer(s)' circuit breaker(s) to attain a higher short-circuit current rating. In this case the manufacturer's label will include the specific manufacturer and type of circuit breaker that must be used to protect the transfer switch.

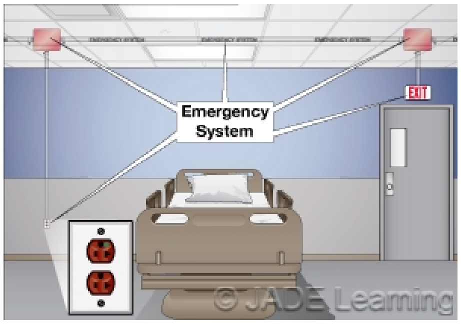
Since the manufacturer may provide multiple short circuit ratings based on several different types of overcurrent devices on the equipment label installed at the factory the exterior of the transfer equipment must be field marked with the appropriate short-circuit rating based on the actual rating of the circuit breaker or fuses installed in the field.

Question 79: According to the manufacturer's label, a transfer switch has a short-circuit withstand and closing rating of 42,000 amps when protected by a Type AB2, 600-amp circuit breaker manufactured by XYZ Electric. Which of the following circuit breakers may be used to protect the transfer switch?

A: Any UL listed 600-amp circuit breaker from any manufacturer.
B: Any 600-amp circuit breaker manufactured by XYZ Electric.
C: A Type AB2, 600-amp circuit breaker manufactured by XYZ Electric.
D: Any instantaneous trip 600-amp circuit breaker.

Question 80: 700.10(A) Emergency Systems. Wiring, Emergency System. Identification.

Question ID#: 1229.0



Receptacles, exposed raceway and cables, and junction boxes of the emergency system must be identified as separate from normal wiring components.

The rules for identifying emergency system wiring have been significantly expanded. In addition to boxes and enclosures, raceways, cables, and receptacles that are part of an emergency circuit or system must now be permanently identified as part of the emergency system.

Emergency systems are legally required systems intended to provide power and illumination ***"essential for human safety."*** (700.2). In order to avoid unintentional modifications or connection of non-essential loads to emergency circuits, all components of an emergency system must be clearly identified. For example, if junction boxes are not properly identified it would be very easy to extend an emergency system circuit to a nonemergency load such as a luminaire or receptacle. A short-circuit in the nonemergency portion of the circuit could cause a circuit breaker to trip and disable part of the emergency system.

Receptacles supplied by the emergency system are required to be identified by a distinctive color or marking on the receptacle or cover plate. Red receptacles and cover plates are often used for this purpose, but other colors could be used. Whatever color or marking is used it must be consistently used to identify the emergency system on the premises. The colors or markings used for the emergency system components must not be used to identify circuits supplied by any optional standby system(s) on the same premises.

Exposed raceways and cables are required to be permanently marked at intervals not exceeding 25 ft. unless junction boxes or enclosures are present that readily identify the cable or raceway as part of the emergency system. Raceways and cables installed above a lay-in ceiling are considered exposed and must be identified if they are part of an emergency circuit or system. Color coding or permanent labels are two methods of identification that are commonly used.

The NEC does not state how other emergency system components are to be identified, only that emergency circuits "***shall be permanently marked so they will be readily identified as a component of an emergency circuit or system."*** (700.10(A)). Boxes and enclosures are typically identified by either color coding or permanent labels.

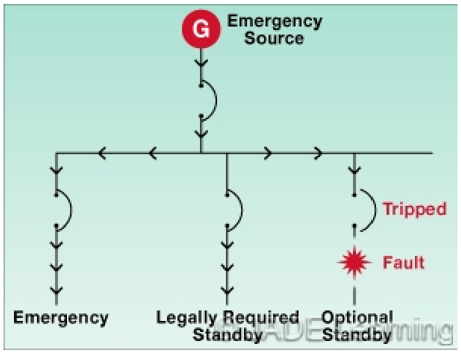
The color chosen to identify emergency system boxes and enclosures should not be the same as used for another system. For example, low-voltage fire alarm circuit junction boxes are often identified by the color red. If red is also used to identify emergency system branch circuits, neither system would be readily identifiable. Larger equipment is typically identified by a permanent label. All transfer switches, generators, and power panels that are part of a legally required emergency system must be identified as components of the emergency system.

Question 80: An emergency system EXIT light circuit is run in EMT above a lay-in ceiling. Junction boxes are installed every 100 ft. Which of the following is an acceptable method to identify the EMT as part of the emergency system?

A: Identifying the EMT with permanent "EMERGENCY CIRCUIT" labels installed at 25 ft. intervals.
B: Color coding the EMT at 30 ft. intervals.
C: Identifying the junction boxes only (Not the EMT) with green paint.
D: Placing red marking tape around the branch circuit conductors.

Question 81: 700.10(B) Wiring, Emergency System. Wiring.

Question ID#: 1230.0



Where an emergency power source such as a generator supplies both emergency and nonemergency loads, the feeder overcurrent devices must be selectively coordinated.

The rules regarding the selective coordination of overcurrent protective devices where an emergency power source supplies both emergency and nonemergency loads have been revised. A new informational note provides two new diagrams illustrating a single emergency source with a common feeder supplying both emergency and nonemergency loads connected to a common bus.

For example, a feeder from an emergency generator to a switchboard may supply both emergency and optional stand-by loads in the switchboard. The emergency circuits are required to be installed in separate vertical sections of the switchboard to physically separate the emergency system wiring from the nonemergency optional stand-by circuits, but the feeder from the source to the switchboard is common to both systems. If the common feeder is protected by an overcurrent device, a fault in a downstream non-emergency circuit could cause the feeder overcurrent device to open and disconnect power to the emergency system.

One method to avoid interrupting power to the emergency system is to not provide overcurrent protection for the feeder(s) between the emergency source and the point where the emergency loads and nonemergency loads are separated. Separate overcurrent protection is provided for each emergency and nonemergency load, but the common feeder is not protected by an overcurrent device. A new Informational Note, Figure 700.10(B)(5)(b)(1), illustrates this arrangement.

Overcurrent protection at the emergency source is permitted in the feeder(s) supplying a common bus in a switchboard or switchgear in accordance with 700.10(B)(5)(b)(2). The overcurrent protective device in the common feeder(s) must be selectively coordinated with the next downstream overcurrent protective device in the non-emergency system. In the event of a fault in the non-emergency system, the downstream non-emergency overcurrent device must open before the overcurrent device in the common feeder. Determining which circuit breaker will open first requires evaluating the trip point of the overcurrent protection devices under various fault conditions to ensure that the downstream non-emergency overcurrent device will always open before the circuit breaker or fuses protecting the common feeder. The selective coordination of the overcurrent devices must be documented by a professional engineer or other qualified electrical system designer and ***"made available to those authorized to design, install, inspect, maintain, and operate the system***." (700.32).

Question 81: A feeder from an emergency generator to a switchboard is protected by 600-amp fuses. A common bus in the switchboard supplies both emergency loads and a 200-amp circuit breaker for optional stand-by loads. Which of the following statements is true?

A: The emergency circuits and optional stand-by system circuits are required to be installed in the same vertical section of the switchboard.
B: Overcurrent protection is not permitted in the feeder from the emergency source.
C: The 600-amp feeder overcurrent device must be selectively coordinated with the 200-amp downstream overcurrent device in the optional stand-by system.
D: Selective coordination of the overcurrent devices is not required.

Question 82: 700.10(D) Wiring, Emergency System. Fire Protection.

Question ID#: 1231.0

In assembly occupancies for not less than 1000 persons, buildings taller than 75 ft., health care facilities where persons are not capable of self-preservation, and educational occupancies with more than 300 occupants, emergency system feeder-circuit wiring and generator control wiring must be protected from exposure to fire.

Emergency system feeder-circuit wiring, equipment, and generator control wiring must be protected from exposure to fire to ensure that the emergency system will operate long enough for large buildings to be safely evacuated. The 2014 NEC required fire protection of emergency system feeder circuit wiring in assembly occupancies for 1000 persons or more and high-rise buildings over 75 ft. in height. The 2017 NEC adds some health care facilities and educational occupancies to the list of occupancies in 700.10(D). Emergency system feeder circuits must now be protected from fire in the following locations:

1) ***Assembly occupancies for not less than 1000 persons.***

2) ***Buildings above 23 m (75 ft.) in height.***

3) ***Health care occupancies where persons are not capable of self-preservation.***

4) ***Educational occupancies with more than 300 occupants.***

In addition to hospitals, there are many types of health care facilities where a person may be incapable of self-preservation. Nursing homes, mental health facilities, even some out-patient surgical clinics will now require fire protection for emergency feeder-circuits.

Although the NEC does not define an educational facility, most building codes define an educational occupancy as the use of a building for educational purposes through the 12th grade. The change will impact public and private schools with an occupant load of more than 300 students and staff if emergency feeder-circuits are installed. Many smaller schools rely on unit-equipment for emergency illumination and do not require emergency feeder-circuits.

One option is to install emergency feeder-circuit wiring in spaces fully protected by an automatic fire suppression system, such as an NFPA 13 fire sprinkler system. If the feeder-circuit conduit or cable assembly is installed above a suspended ceiling, sprinklers must be installed to protect the above ceiling space. The feeder-circuit conductors may also be protected by a 2-hour fire-rated listed assembly that contains only emergency circuits or by other listed 2-hour rated fire protection systems.

A final option is to encase the feeder-circuit conduits in a minimum of 2 in. of concrete. Concrete encasement is a practical alternative where feeders are installed in raceways within or below a concrete slab. Any portion of the raceway that extends above the concrete slab would still require fire protection by one of the means specified in 700.10(D).

Emergency system transfer switches, transformers and panelboards in the four occupancies listed in 700.10(D) must be located in spaces that are fully protected by an automatic fire suppression system or installed in a room or space constructed to provide a 2-hour fire resistance rating.

Expanding the fire protection requirements for emergency systems will help ensure that emergency lighting, public safety communication systems, and other systems necessary for the safety of the occupants in the buildings covered by 700.10(D) will continue to work for a period of time in the event of a fire.

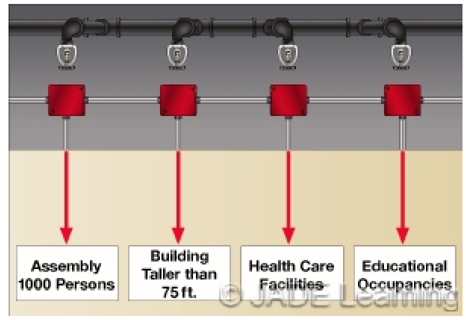
Question 82: A public school has an occupant load of 550 people including students and staff. A 100-amp emergency feeder-circuit is installed in metal raceway above the ceiling in the cafeteria. Which of the following is an acceptable method of fire protection for the feeder-circuit?

A: Installing a 1-hour rated lay-in ceiling in the cafeteria.
B: Installing the feeder-circuit conductors in rigid metal conduit.
C: Installing a NFPA 13 fire sprinkler system to fully protect the space above the ceiling.
D: Encasing the feeder-circuit raceway in 1 in. of concrete.

Question 83: 700.10(D)(1) Wiring, Emergency Systems. Fire Protection. Feeder-Circuit Wiring.

Question ID#: 1232.0

Educational occupancies with more than 300 occupants and health care occupancies where persons are not capable of self-preservation have been added to the list of occupancies in 700.10(D) that require fire protection for emergency feeder-circuit wiring.



One of the ways to provide fire protection for emergency feeder circuit wiring is to install the cable or raceway in spaces or areas that are fully protected by an approved automatic fire suppression system.

The list of acceptable fire protection conditions for emergency feeder circuit wiring in 700.10(D)(1) has also been revised. The separate entry for listed thermal barriers has been replaced by ***a listed fire resistive cable system.*** A new informational note includes listed thermal barriers as a type of ***listed electrical circuit protective system.*** Listed thermal barriers can still be used as fire protection for feeder-circuit wiring. There are five possible ways to provide fire protection for feeder-circuit wiring.

1) The cable or raceway is installed in spaces or areas that are fully protected by an approved automatic fire suppression system.

2) ***The cable is protected by a listed electrical circuit protective system with a minimum 2-hour fire rating.***

Listed thermal barriers and other electrical circuit protective systems are tested in accordance with UL 1724, ***Fire Tests for Electrical Circuit Protection Systems***.

3) The cable or raceway is a listed fire-resistive cable system. (NEW)

Listed fire-resistive cable systems are available with a 2-hour fire resistive rating when installed in accordance with the manufacturer's instructions and the listing requirements for the specific fire-resistive system. For example, some fire-resistive cables must be installed in steel EMT that is supported every 5 ft. to obtain a 2-hour fire rating. Additional requirements for fire-resistive cable assemblies are found in NEC Article 728, Fire-Resistive Cable Systems.

4) The cable or raceway is protected by a listed fire rated assembly that has a minimum fire rating of 2 hours and contains only emergency circuits.

5) The cable or raceway is encased in a minimum of 2 in. of concrete.

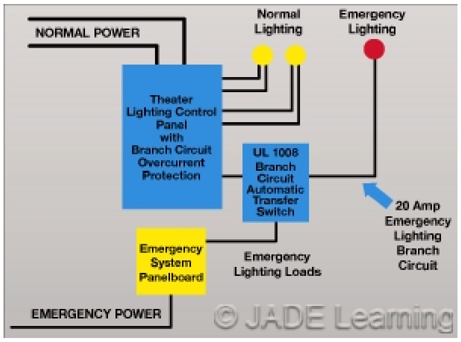
UL publishes a Fire Resistance Directory that provide the details on how to construct an assembly to obtain a 2-hour fire resistance rating. Concrete encasement also has proven effective in providing fire protection. The cable or raceway must be encased by 2 in. of concrete on all sides.

Question 83: Emergency feeder-circuit wiring is installed in a surgical clinic where patients are temporarily incapable of self-preservation. Which of the following is NOT an acceptable method of fire protection?

A: Installing the feeder-circuit in rigid metal conduit encased in 1 in. of concrete.
B: Protecting the feeder-circuit raceway with a listed 2-hour rated fire rated assembly.
C: Installing a fire-resistive cable system in EMT in accordance with the listing requirements for the system.
D: Installing the feeder-circuit in a space fully protected by an approved automatic fire sprinkler system.

Question 84: 700.25 Control Emergency Lighting Circuits. Branch Circuit Emergency Lighting Transfer Switch.

Question ID#: 1233.0



A branch circuit emergency lighting transfer switch can by-pass the dimming function in a theater lighting control panel and fully illuminate the emergency lighting.

Branch circuit emergency lighting transfer switches are a new class of transfer switch designed to transfer only emergency lighting loads from the normal power supply to an emergency source. As the name implies, a branch circuit emergency lighting transfer switch is connected on the load side of a branch circuit overcurrent device.

Branch circuit emergency lighting transfer switches are permitted to be used with emergency lighting branch circuits rated no more than 20 amperes. Listed branch circuit emergency lighting transfer switches are tested in accordance with UL 1008 and are not required to meet the mechanically held requirements in 700.5(C). With the increasing use of complex lighting controls, the new class of transfer switches provides a needed option for the control of emergency illumination.

For example, in theaters and similar locations some of the luminaires are used for both normal and emergency lighting. Lighting levels are controlled by a dimmer system listed for use in emergency systems. If the normal power fails, emergency power to the dimmer system is provided through a UL 1008 listed emergency transfer switch in the feeder-circuit to the dimmer system. Automatic lighting control relays by-pass the dimming function to fully illuminate the emergency lighting. The transfer switch is sized to accommodate the feeder conductors supplying the dimmer system, even though the emergency lighting load is much less than the normal lighting load.

Instead of installing a transfer switch in the feeder circuit supplying the dimmer, a branch circuit emergency lighting transfer switch can be installed on the load side of the lighting branch circuit overcurrent device(s). Branch circuit emergency lighting transfer switches need only be installed for the number of branch circuits supplying the emergency lighting loads. If the normal power fails, the emergency lighting branch circuits are transferred directly to the emergency source.

Question 84: What is the maximum rating of an emergency lighting branch circuit supplied through a branch circuit emergency lighting transfer switch?

A: 15 amperes.
B: 20 amperes.
C: 25 amperes.
D: 30 amperes.

Question 85: 702.5 Optional Standby Systems. Transfer Equipment.

Question ID#: 1234.0

Optional standby transfer equipment must be marked to show the short-circuit rating of the switch based on the actual overcurrent device installed to protect the transfer switch.

Optional standby systems are:

Those systems intended to supply power to public or private facilities or property where life safety does not depend on the performance of the system. These systems are intended to supply on-site generated power to selected loads either automatically or manually.

A key component of any standby system is the transfer equipment that is used to switch from the normal power to the standby power source. Transfer equipment is required for all standby systems that utilize an electric utility supply as a normal or standby power source.

Transfer equipment for optional standby systems must now be field marked to indicate the short-circuit current rating of the transfer switch equipment based on "***the specific overcurrent protective device type and settings protecting the transfer equipment."*** There is an identical requirement for transfer equipment that transfers power to an emergency system.

Transfer switch manufacturers typically refer to short circuit current ratings for transfer equipment as the Short-Circuit Withstand and Closing Rating or WCR of the equipment. In order to comply with the UL 1008 product standard, transfer switch equipment must be able to withstand the available fault current until a circuit breaker or fuse opens and clears the short circuit or ground-fault. This means that the short circuit rating of the transfer switch is directly related to the time it takes a fuse or circuit breaker to open and clear the fault. The same transfer switch may have different short-circuit withstand ratings depending on the type and rating of the overcurrent device protecting the transfer switch.

Some transfer switches may also be evaluated for use with a specific manufacturer's circuit breakers in order to get a higher short-circuit current rating. In this case the manufacturer's label will include the specific manufacturer and type of circuit breaker that is required to get the stated short-circuit rating.

Since the manufacturer does not know the specific type of overcurrent device that will be installed, the exterior of the transfer equipment must be field marked with the appropriate short-circuit current rating based on the type and rating of the overcurrent device installed to protect the equipment.

The manufacturer may provide several short circuit ratings based on different types or overcurrent devices that may be used to protect the transfer switch equipment. The electrical contractor will need to field mark the equipment to indicate which one of the short circuit ratings apply.

The marking requirement is not just for transfer switches installed at commercial occupancies. Since an exception is not provided for dwelling units, optional stand-by systems at one- and two-family dwellings must be marked with the applicable short-circuit current rating.

Question 85: Transfer equipment manufacturers refer to the short-circuit current rating for transfer equipment using which of the following terms?

A: Current Limiting Transfer Rating (CLT).
B: Short-Circuit Withstand and Closing Rating (WCR).
C: Maximum Interrupting Rating (MIR).
D: Optional Standby Rating (OSR).

Question 86: 702.12(C) Outdoor Generator Sets. Power Inlets Rated at 100 Amperes or Greater, for Portable Generators.

Question ID#: 1235.0

Power inlets rated 100 amperes or more that are used with outdoor portable generators must be listed for the intended use.

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This revision provides new requirements for power inlets rated at 100 amps or more that are used with outdoor portable generators. The primary reason for the new requirements is to ensure that disconnecting the power inlet under load does not occur unless the inlet device is rated for load-break operation. So the rule does not apply to the generator directly. The rule applies to the equipment (power inlet) mounted on the building that will receive power from a portable outdoor generator set through a cord connection to the portable generator.

Under this new requirement, equipment that contains power inlets intended for connection to a generator source must be listed for the intended use. This listing should cover most of the safety concerns if the instructions included in the listing and labeling are followed. But an additional new rule is that systems with power inlets for portable generators must be equipped with an interlocked disconnecting means if the power inlet is rated 100 amperes or more. A portable generator capable of supplying a load or 100 amperes or more is typically either mounted on skids or a trailer. The generator may or may not be located within sight of the power inlet on the building it will supply. Removing the power supply cord from a power inlet and opening a load of 100 amperes or more could result in a dangerous arc resulting in injury, as well as damage to the equipment.

The interlocked disconnecting means will prevent a person from inserting or removing a flexible cord connector into the power inlet while the disconnecting means is in the closed position and thus possibly exposing a person to the hazard of using the connector and inlet to interrupt the load.

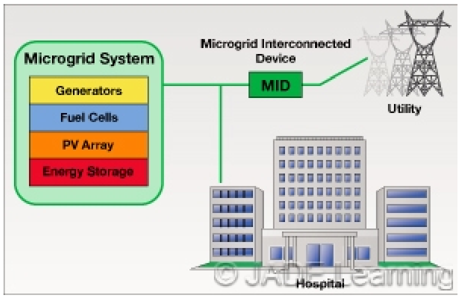
Two exceptions to the interlocking disconnect requirement come along with the new rule. Neither exception eliminates the requirement for listing. Exception No. 1 allows the interlocking means to be eliminated if the inlet device itself is rated as a disconnecting means, that is, if the inlet device is rated for load-break operation. Exception No. 2 says that in supervised industrial installations, if there is a permanent space that is identified for the portable generator, and if that space is located within the line of sight of the power inlets, the disconnecting means is not required to be interlocked with the inlets and the inlets are not required to be rated as disconnects.

Question 86: The new requirement for a disconnect interlocked with the power inlet applies to which one of the following inlets for outdoor portable generators?

A: To all power inlets for portable generators.
B: To power inlets rated 60 amperes or more.
C: To power inlets rated 100 amperes or more.
D: To all equipment with inlet devices rated as disconnects.

Question 87:   705.2 Interconnected Electric Power Production Sources. Definitions. MID.

Question ID#: 1236.0



A microgrid interconnect device (MID) is an interface device which allows the microgrid to connect to the utility grid so the microgrid can run in parallel to the utility, and to disconnect from the utility so the microgrid can provide power independently from the utility grid.

New definition: ***Microgrid Interconnect Device (MID). A device that allows a microgrid system to separate from and reconnect to a primary power source.***

Microgrid systems may include multiple power production sources, energy storage systems, and loads, all interconnected with a primary power source. In most areas of the United States the primary power source is the electric utility power grid. Since the utility grid relies on high voltage overhead transmission lines to transmit electricity over long distances it is vulnerable to damage from storms or other natural disasters. Microgrid systems are essentially small-scale distribution systems with on-site electric power production. A microgrid system is capable of operating independently of the electric utility when needed.

The device that enables a microgrid system to disconnect from and reconnect to the utility power grid or other primary power source is called a Microgrid Interconnect Device or MID. Adding a definition was needed to eliminate confusion as these devices have been referred to by various terms, such as islanded interconnect device.

A microgrid interconnect device is required for any connection between the microgrid system and the utility power grid. If there are multiple points of connection between the microgrid system and the utility power grid, there must be a microgrid interconnect device for each connection. Multimode inverters or similar inverter devices identified for use with interactive systems may also include the functions of a microgrid interconnect device.

Additional requirements for microgrid interconnect devices are found in Part IV of Article 705. A microgrid interconnect device (MID) must either be listed by a third-party testing agency or field labeled to indicate that the MID is suitable for the application. Interactive or multimode inverters may incorporate the functions of a microgrid interconnect device when identified for use with interconnected power production sources.

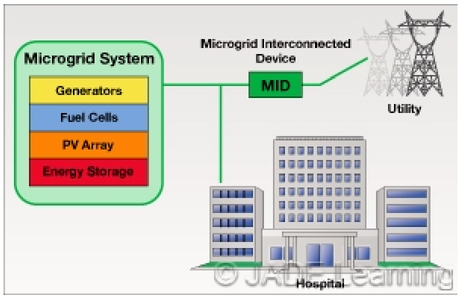
A new Part IV has been added to Article 705 for Microgrid Systems. It is likely that the rules in the NEC will be expanded as microgrid systems become more common.

Question 87:   A college campus has a microgrid system with connections to two separate utility owned substations. How many microgrid interconnect devices are required?

A: 0.
B: 1.
C: 2.
D: 4.

Question 88:   705.2 Interconnected Electric Power Production Sources. Definitions. Microgrid System.

Question ID#: 1237.0



A microgrid system can operate in parallel with the utility power grid or disconnect from the utility grid and operate as a standalone power source.

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New: Part IV Microgrid Systems.

Microgrid systems are electric power generation and distribution systems that may include any combination of power production sources, energy storage systems, and connected loads. A new Part IV has been added to Article 705 Interconnected Electric Power Production Sources. The new Part IV was needed because unlike other interconnected systems, a microgrid is capable of operating independently of the electric utility grid as a separate microgrid system. When a microgrid system is operating in parallel with a primary power source, such as the utility power grid, it falls under the general rules of Article 705. When the microgrid disconnects from the primary power source it must also comply with Part IV.

Microgrid systems are permitted to disconnect from the primary power source and continue to supply the loads connected to the microgrid system. The system also must have the capability to establish a synchronous transition and reconnect to the primary power source as needed. In areas where the local utility electric grid is unreliable, a microgrid system can continue to supply a local grid system until power is restored. For example, an industrial plant could employ a microgrid system to remain in operation. Where time of use utility rates are in effect, it may be economically beneficial to disconnect from an electric utility source during peak rate hours. Since a microgrid system is essentially a scaled down version of the larger utility power grid that does not rely on long distance overhead power lines, a microgrid system could also be used to supply essential facilities such as a fire station or hospital campus in the aftermath of a natural disaster.

The device that allows a microgrid system to disconnect and reconnect to the utility power grid or other primary power source(s) is called a microgrid interconnect device or MID. A microgrid interconnect device is required for any connection between the microgrid and a primary power source. An MID must be either listed by a third party testing agency or field labeled by an agency acceptable to the authority having jurisdiction. Overcurrent devices must be located to provide overcurrent protection from all of the interconnected sources of power.

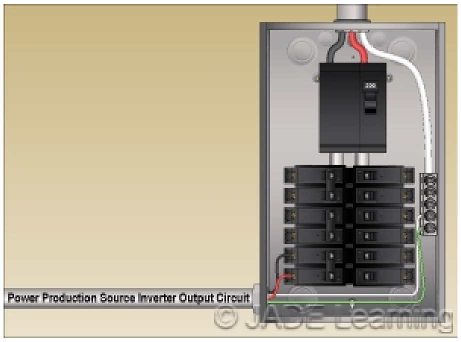
As solar photovoltaic, wind, and other local power production sources are coupled with emerging energy storage technology it is likely that microgrid systems will become more numerous. A microgrid system can power a single building, a campus facility, and potentially an entire community. It is likely that Part IV will be significantly expanded in the next NEC.

Question 88:   How many different power production sources are permitted to supply a microgrid system?

A: Any number of power production sources in parallel with a utility supply.
B: 2 power production sources in parallel with a utility supply.
C: A maximum of 10 power production sources.
D: Only 1 power production source is permitted.

Question 89: 705.12(B) Interconnected Electric Power Production Sources. Point of Connection. Load Side.

Question ID#: 1238.0



The output of an alternative power source can be connected to the load side of the primary power source at a dedicated circuit breaker or fusible disconnect switch.

Section 705.12(D) ***Utility Interactive Inverters*** in the 2014 NEC has been retitled as 705.12(B) ***Load Side*** in the 2017 NEC. Any type of electric power source, not just the output of a utility interactive inverter, is now permitted to be connected to the load side of the primary power source service disconnect. A utility power source is now called a primary power source. Although the utility power grid is usually the primary power source, there may be situations where the primary power source is not the utility power grid.

Utility interactive inverters are typically associated with photovoltaic power sources and battery type energy storage systems. There is no reason why the output of other electric power sources such as wind turbines and stand-by generators should not be permitted to connect to the load side of the primary power service disconnect if the same requirements are met for these systems.

The ampacity requirements for feeders, tap conductors and bus bars supplied by more than one power source have also been revised and are easier to understand. Each power source interconnection to the primary source is still required to be made at a dedicated circuit breaker or fusible disconnect switch.

A connection is now permitted at either end, but not both ends, of the bus in a center-fed panelboard in a dwelling. This practice was permitted for center-fed panels in dwellings prior to the 2008 NEC. The change will once again permit a photovoltaic or other power source to be connected to either end of the bus in a center-fed panelboard, but this is only permitted for dwellings. There has been no evidence from pre-2008 installations to suggest that the current density on the busbar will exceed the rating of the busbar in a residential installation. The sum of 125% of the power source(s) output circuit current plus the rating of the overcurrent device protecting the busbar must not exceed 120% of the current rating of the busbar.

Question 89: A PV power source is connected to one end of a 200-amp rated bus in a center-fed panel at a dwelling. The rating of the main-breaker plus 125% of the PV output circuit current shall not exceed which of the following?

A: 240 amperes.
B: 200 amperes.
C: 220 amperes.
D: 175 amperes.

Question 90: 705.22 Interconnected Electric Power Production Sources. Disconnect Device.

Question ID#: 1239.0

A warning sign is required for all power source disconnects that may be energized from both directions.

Where power production sources are interconnected in parallel with other power source(s), such as the utility power grid, both sides of the power source disconnect switch or circuit breaker may be energized, even when the switch is in the OFF position. This means that the terminals and blades of a knife-blade switch that are typically de-energized when the switch is off, will remain energized and pose a shock hazard to those who may be servicing the equipment. The disconnect device must now be marked in accordance with 690.13(B) to warn of the electric shock hazard.

WARNING

ELECTRIC SHOCK HAZARD
TERMINALS ON THE LINE AND LOAD SIDES

MAY BE ENERGIZED IN THE OPEN POSITION

Although 690.13(B) applied only to PV systems in the 2014 NEC, the warning sign is now required for all interconnected power production source disconnects that may be energized from both directions. The warning sign or label must comply with the requirements of 110.21(B) and is not permitted to be handwritten. The sign or label must be suitable for the environment where it is installed.

As the number of interconnected electric power production sources continues to increase, the number of disconnecting means that may be energized from two directions even when in the open position will also increase. It is essential that these disconnects be clearly identified with a warning sign or label to inform electricians and maintenance technicians of the electrical hazard.

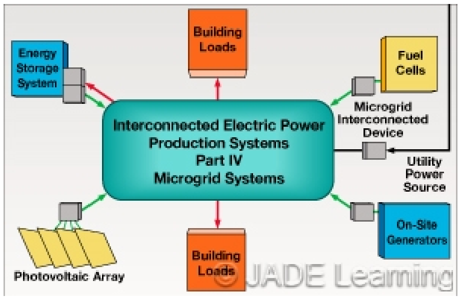
Minor editorial revisions were made in the current ratings required for the disconnecting means. The disconnect device for a power production system is now required to be rated for the maximum circuit current, the available short circuit current, and the voltage that is available at the device terminals. Including the short circuit current rating rather than the interrupting rating means that the disconnect must be rated to withstand the available short circuit current until an overcurrent device opens. The disconnecting means may be manual or power operated switch(es) or circuit breaker(s), must be readily accessible and must be capable of being locked in the open position in accordance with 110.25.

Question 90: A fusible disconnect switch used as the disconnecting means for an interconnected power production source may be energized from both sources. Which of the following parts is certain NOT to be energized when the switch is OFF?

A: The switch knife blades.
B: The load terminals.
C: The fuses.
D: The equipment grounding terminal.

Question 91: 705, Part IV Interconnected Electric Power Production Sources. Microgrid Systems.

Question ID#: 1240.0



Microgrid systems can consist of on-site generators, PV arrays, fuel cells, and energy storage systems.Â Microgrid systems can connect or disconnect from the utility power source through a microgrid interconnect device.

New: Part IV Microgrid Systems.

Microgrid systems are electric power generation and distribution systems that may include any combination of power production sources, energy storage systems, and connected loads. A microgrid system is an interconnected electric power production source that operates in parallel with a primary power source, but is also capable of supplying loads while disconnected from its primary power source.

A new Part IV has been added to Article 705 Interconnected Electric Power Production Sources. The new Part IV was needed because unlike other interconnected systems, a microgrid is capable of operating independently of the electric utility grid as a separate microgrid system. When a microgrid system is operating in parallel with a primary power source, such as the utility power grid, it falls under the general rules of Article 705. When the microgrid disconnects from the primary power source it must also comply with Part IV.Â

Microgrid systems are permitted to disconnect from the primary power source and continue to supply the loads connected to the microgrid system. The system also must have the capability to establish a synchronous transition and reconnect to the primary power source as needed. In areas where the local utility electric grid is unreliable, a microgrid system can continue to supply a local grid system until power is restored. For example, an industrial plant, could employ a microgrid system to remain in operation. Where time of use utility rates are in effect, it may be economically beneficial to disconnect from an electric utility source during peak rate hours. Since a microgrid system is essentially a scaled down version of the larger utility power grid that does not rely on long distance overhead power lines, a microgrid system could also be used to supply essential facilities such as a fire station or hospital campus in the aftermath of a natural disaster.

The device that allows a microgrid system to disconnect and reconnect to the utility power grid or other primary power source(s) is called a microgrid interconnect device or MID. A microgrid interconnect device is required for any connection between the microgrid and a primary power source. An MID must be either listed by a third party testing agency or field labeled by an agency acceptable to the authority having jurisdiction. Overcurrent devices must be located to provide overcurrent protection from all of the interconnected sources of power.

As solar photovoltaic, wind, and other local power production sources are coupled with emerging energy storage technology it is likely that microgrid systems will become more numerous. A microgrid system can power a single building, a campus facility, and potentially an entire community. It is likely that Part IV will be significantly expanded in the next NEC.

Question 91: Which of the following is a microgrid system?

A: A PV array that supplies power directly to the utility grid.
B: An emergency generator at a hospital that operates during a power outage.
C: A system that includes power production sources and loads interconnected with the utility power grid.
D: The utility power grid.

Question 92: Article 706 Energy Storage Systems.

Question ID#: 1241.0

Energy Storage Systems are listed systems that store energy for use at a future time.

Many solar photovoltaic and wind turbine electric power production facilities are capable of generating more electricity than can be used at certain times of the day. This creates a need to store the excess power generated for use at a later time. Article 706 has been added to address some of the safety concerns associated with the complex energy storage systems that are being developed to fill this need.

The new article defines an Energy Storage System (ESS) as, "***One or more components assembled together capable of storing energy for use at a future time."*** Although storage batteries covered by Article 480 may be a component of an ESS, the systems covered by Article 706 will typically have a greater energy storage capacity and more complex controls. Self-contained lithium-ion Energy Storage Systems rated up to 1 Mega Watt are available today and both vanadium redox and iron redox flow batteries are being tested. Mechanical energy storage systems that store energy using fly-wheel technology have also been developed.

Three sub-types of Energy Storage Systems are described: (1) self-contained energy storage systems, (2) pre-engineered energy storage systems that are assembled on-site using matched components, and (3) other energy storage systems. With the exception of lead-acid batteries, all components of an ESS, including monitors, controls, fuses, circuit breakers, power conversion equipment and energy storage, must be listed. A self-contained ESS must be listed as a complete system.

Whatever type of energy storage system is used a disconnecting means must be provided that will disconnect all ungrounded conductors derived from the energy storage system. The disconnecting means must be readily accessible and within sight of the energy storage system.

Multiple Energy Storage Systems of any type are permitted to be installed in the same building or structure. A permanent plaque or directory that shows the location of all Energy Storage Systems and other power sources on the premises must be installed at each service equipment location and at the location of all other interconnected power sources including other Energy Storage Systems.

With the increasing emphasis on microgrid systems and stand-alone power production facilities that rely on wind turbines or PV systems as a primary power source, the use of energy storage systems will become increasing important. Large scale energy storage systems may also reduce the need for electric utilities to build more power generating stations.

Question 92: Which of the following components of an Energy Storage System is NOT required to be listed?

A: Lithium-ion batteries.
B: Power conversion equipment.
C: Lead-acid batteries.
D: Circuit breakers.

Question 93: 708.10(A)(2) Critical Operations Power Systems. Feeder and Branch Circuit Wiring. Identification. Receptacle Identification.

Question ID#: 1242.0

Nonlocking-type, 125-volt, 15- and 20-ampere receptacles supplied by a critical operations power system (COPS) are now required to have an illuminated face or an indicator light to indicate that power is on.

Nonlocking-type, 125-volt, 15- and 20-ampere receptacles supplied by a critical operations power system (COPS) are now required to have ***"an illuminated face or an indicator light to indicate that power is on."*** The requirement for an illuminated face or an indicator light is in addition to the existing requirement that all receptacle outlets supplied by the COPS be identified by a distinctive color receptacle or a cover with a distinctive color. The NEC does not specify a particular color; any distinctive color can be used.

Critical operations power systems are installed in facilities that have been identified by government authorities as vital to national security, public health or safety, or the economy. For example, most communities have at least one building that is designated as an Emergency Operations Center. Other examples of facilities that may be deemed vital, include air traffic control towers, hospitals, fire stations and police stations.

The critical operations power system (COPS) supplies the lights, receptacles and other loads that are essential to the operations of the facility. Other receptacles that are not connected to the COPS may be present in the same area. In the event normal power fails or a circuit breaker trips, the illuminated face or indicator light of a receptacle that is connected to the COPS system will make it easy to find. The illuminated face will also verify that the COPS receptacles are energized. The illuminated face of the receptacle will also make it easy to transfer portable equipment, such as computers, radio chargers, or other equipment needed during an emergency from a receptacle that has lost power to an energized receptacle.

Only the non-locking type, 125-volt, 15- and 20-ampere COPS receptacle outlets are required to be identified by both an illuminated face or an indicator light to indicate that power is on and by a distinctive color receptacle or cover plate.

All receptacle outlets (including the 125-volt, 15- and 20- ampere rated non-locking type) connected to the Critical Operations Power System (COPS) are required to be identified by a distinctive color receptacle or by a receptacle cover with a distinctive color. Although the NEC does not specify a specific color for the receptacle or cover, whatever color is used should be consistent within the facility to ensure that receptacles connected to the COPS systems can be readily distinguished. The only exception to the distinctive color requirement is where the critical operations power system supplies a stand-alone building and the entire building has been designated as critical.

Question 93: Non-essential receptacles and covers are white with white covers. Which of the following is an acceptable method to identify nonlocking type, 125- volt, 20-ampere receptacles connected to the COPS?

A: White receptacles with a power-on indicator light and white covers.
B: White receptacles with red covers.
C: Red receptacles with a power on indicator light and white covers.
D: Red receptacles with white covers.

Question 94: Article 710 Stand-Alone Systems.

Question ID#: 1243.0

A stand-alone system operates independently of the utility grid.

The new Article 710, Stand-Alone Systems, was added because the subject does not fit into Article 705, Interconnected Power Production Sources, and also differs from the DC Microgrids covered by the new Article 712. Some rules in articles that cover specific power production sources such as PV, wind, and fuel cells have been copied into Article 710. Article 710 covers all such sources if they are operated as stand-alone systems but also covers other sources like generators. Article 705 applies when there is a utility connection in addition to the stand-alone system.

A Stand-Alone System is defined in Article 100 as "A system that supplies power independently of an electrical production and distribution network." An example of a stand-alone system could include several photovoltaic panels with batteries operating street signs, lights, or parking meters, all of which are in common use. The rating of a stand-alone system is not limited so it could be as large as needed for an entire building or as small as needed for a single light or sign. The capacity of the power source must not be less than the load of the largest single utilization equipment connected to the system.

The general requirement is that the premises wiring supplied by a stand-alone system must meet the same requirements as premises wiring supplied by a feeder or utility service, but Article 710 permits the conductors from the stand-alone source to the building or structure to be smaller than required to serve the calculated load of the building or structure it supplies.

The size of conductors from the stand-alone power source to the building or structure disconnecting means is based on the total output rating(s) of the stand-alone power sources. For example, a stand-alone PV power source with an output rating of 50 amperes supplies an off-grid dwelling. The ampacity of the conductors from the stand-alone source to the dwelling disconnecting means need not be larger than 50 amperes. The rating of the disconnecting means and wiring within the dwelling must meet the NEC requirements for a dwelling unit.

All equipment used as a component of the stand-alone system must be listed or field labeled for the intended use.

The new rules also permit the use of single-phase 120/240 volt three-wire distribution equipment with a single-phase two-wire 120 volt supply under the condition that no 240-volt or multiwire branch circuits are permitted. Signs or labels warning against the use of multiwire branch circuits are also required. The capacity of the power sources is also limited to less than the rating of the neutral bus in the service equipment. These conditions are established to avoid overloading neutral conductors.

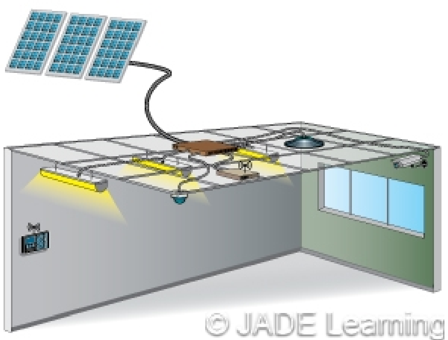
For example, a small mobile office is set up with service equipment and a panelboard for a 3-wire utility supply, but is relocated to where it is instead supplied by a single 120 volt stand-alone source. The capacity of the neutral bus in the service equipment must be greater than the capacity of the source because the full ampere capacity of the source will be carried by the neutral bus. All circuits have to be two-wire 120 volt circuits. Both buses intended for ungrounded conductors could be connected to the same 120 volt ungrounded conductor in order to provide power to all circuits in the panelboard. However, all loads would have to be 120 volts and no multiwire branch circuits are permitted. The load on the neutral bus would be the sum of the currents in all circuits supplied from both ungrounded buses.

Question 94: Which of the following WOULD NOT be an example of a Stand-Alone System?

A: A self-contained PV powered stop sign.
B: A system supplied by a diesel generator that is the sole source of power for a building.
C: A PV source operating in parallel with a utility supply.
D: A PV-powered parking meter.

Question 95: Article 712 Direct Current Microgrids.

Question ID#: 1244.0



A Direct Current Microgrid uses onsite dc power sources such as PV arrays, fuel cells or wind turbines to supply dc loads. DC microgrids do away with the need to convert ac power into dc power for LED lighting and many electronic loads.

Article 712 has been added to address the increasing use of direct current (DC) microgrid systems. DC microgrids have been used in telecommunications and data centers for several years and are now an option for government centers, university campuses and business facilities that seek make use of the power generated by on-site DC power production facilities such as PV arrays or wind turbines.

The alternating current (AC) electricity supplied to our homes and businesses by the electric utility must be converted to direct current (DC) to supply our computers, televisions and LED luminaires. It would be much more efficient if DC electricity generated on-site by PV arrays, wind turbines or fuel cells could be used to power the DC loads. Utilizing direct current power sources with a DC microgrid also eliminates the synchronization required when interconnecting AC power sources.

A DC microgrid system utilizes on-site dc power sources to supply dc loads. Although both ac and dc systems may be installed on the same premises, a dc microgrid system is not typically directly connected with the primary ac power source. If there is an interconnection with the primary ac power source, the interconnection must comply with Article 705.

Article 712 provides the following definition of a dc microgrid system.

Direct Current Microgrid (DC Microgrid). A direct current microgrid is a power distribution system consisting of more than one interconnected dc power source, supplying dc-dc converter(s), dc load(s), and/or ac load(s) powered by dc-ac inverter(s).

Several other definitions specific to DC microgrid systems are found in 712.2 including definitions for reference grounded DC systems and resistively grounded systems. DC microgrids operating at more than 300 volts between conductors must be either reference-grounded DC systems or resistively grounded DC systems.

Power sources may include PV arrays, fuel cells or wind turbines, as well as energy storage systems such as storage batteries. There must be a readily accessible disconnecting means for each of the interconnected dc power sources. For example, if the DC Microgrid is supplied by a PV system and a fuel cell system a disconnect is required at each location. The disconnecting means must be lockable in the open position.

Each DC power source must be field marked with the maximum available DC short-circuit current on the microgrid. The marking must include the date the short-circuit calculation was performed.

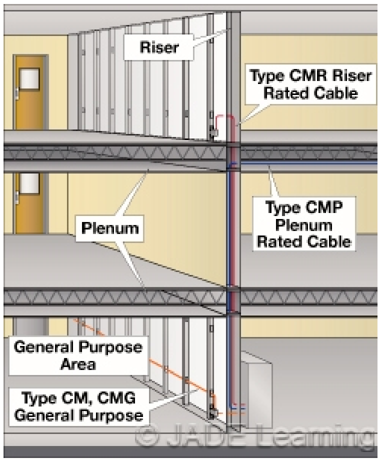
All equipment used in dc circuits must be listed and labeled for dc use. Ungrounded dc system conductors must be identified as required by 210.5(C)(2) for branch circuits and 215.12(C)(2) for feeders.

Question 95: Which of the following is a dc microgrid system?

A: A PV array that supplies power directly to the electric utility power grid.
B: A PV array, fuel cell and dc distribution wiring supplying LED luminaires.
C: An emergency generator at a hospital.
D: A storage battery that supplies emergency lighting.

Question 96: 725.3(M), (N) Class 1, Class 2, & Class 3 Remote-Control, Signaling, & Power-Limited Circuits. Cable Routing Assemblies, Communications Raceways.

Question ID#: 1245.0



Cable types and cable routing assemblies for Remote Control and Signaling cables and Communications cables must be suitable for the location where they are installed.

Although Article 725 in the 2014 NEC recognized the installation of Class 2, Class 3, and PLTC cables in cable routing assemblies and communications raceways, specific installation guidance was missing. Paragraphs M and N now refer to the installation requirements for cable routing systems and communications raceways in Article 800.

The definition of cable routing assembly in Article 100 was also revised to specifically include Class 2, Class 3 and Type PLTC cables.

Cable routing assembly. A single channel or connected multiple channels, as well as associated fittings, forming a structural system that is used to support and route communications wires and cables, optical fiber cables, data cables associated with information technology and communications equipment, Class 2, Class 3, and Type PLTC cables, power-limited fire alarm cables in plenum, riser, and general-purpose applications.

General-purpose cable routing assemblies, riser cable routing assemblies, and plenum cable routing assemblies are covered in Table 800.154(c). Cable routing assemblies installed in a plenum, such as the return air space above some suspended ceilings, must be listed for use in a plenum. Cable routing assemblies used to support vertical cable runs penetrating more than one floor or enclosed in vertical shafts must either be a listed riser cable routing assembly or a listed plenum cable routing assembly. General-purpose cable routing assemblies and communications raceways are not permitted to be used where plenum or riser ratings are required.

Table 800.154(b) provides similar requirements for listed general purpose communications raceways, riser communications raceways, and plenum communications raceways. Communications raceways must also comply with the requirements for electrical nonmetallic tubing (ENT) in 362.24 through 362.56. Listed communications raceways are permitted to be installed as innerduct inside of a listed raceway.

The definition of communications raceway was also revised to include cables other than just communications cables.

Communications raceway. An enclosed channel of nonmetallic materials designed expressly for holding communications wires and cables; optical fiber cables; data cables associated with information technology and communications equipment; Class 2, Class 3, and PLTC cables; and power-limited fire alarm cables in plenum, riser, and general-purpose applications.

Additional installation requirements for cable routing systems and communications raceways are found in 800.110(C), which describes the support requirements for cable routing assemblies, and 800.113, which describes which types of cables, raceways and cable routing assemblies can be installed in various building locations. Both cable routing assemblies and communications raceways must be listed in accordance with 800.182.

The similarities in the installation of communications wires and cables and Class 2,
Class 3, and Type PLTC cables make it logical that such cables be permitted to be installed within cable routing assemblies and communications raceways. The new language in 725.3(M) and (N) and the revisions to the definitions in Article 100 makes it clear that such installations are permitted.

Question 96: Which one of the following is permitted to be installed in an above ceiling space used as a return air plenum?

A: A listed riser cable routing assembly.
B: A listed general-purpose cable routing assembly.
C: A listed plenum cable routing assembly.
D: A listed general-purpose communications raceway.

Question 97: 725.144 Class 1, Class 2, and Class 3 Remote-Control, Signaling, & Power-Limited Circuits. Transmission of Power and Data.

Question ID#: 1246.0

Table 725.144 displays the amount of current that each conductor can carry when the conductor is in a 4-pair cable bundled with other 4-pair cables.

Class 2 and Class 3 cables that transmit data may also carry power to connected devices, such as Internet Protocol (IP) security cameras. Although the current carried by a single conductor is very small, when cables are bundled together heat can still build up in the cable bundle and cause the conductor insulation to overheat and fail. ***Section 725.144 Transmission of Power and Data*** provides requirements intended to limit the heat build-up within cable bundles. All conductors carrying power for the data circuits must be copper and the current on the conductors shall not exceed the current rating of the cable connectors.

Table 725.144 and Note 2

New Table 725.144 shows the amount of current that a 4-pair (8-conductor) cable with copper conductors can carry. As would be expected, each conductor in a 4-pair cable can carry less current if a larger number of 4-pair cables are bundled together. The new Table limits the allowable ampacity of conductors to reduce heat build-up when cables are bundled together.

Table 725.144 is based on 4-pair, Class 2 or Class 3 cables with each conductor carrying current in an ambient temperature of 86Â°F (30Â°C). Note 2 of the Table permits the ampacity to be increased by a factor of ***1.4*** whenever only half of the conductors are carrying current.

For example, in Table 725.144, the allowable ampacity of each conductor in a 4 pair, No. 24 AWG, 60Â°C rated, Type CL2 cable is 2 amperes. If 38 cables are bundled together and all of the conductors are carrying current, the allowable ampacity of each conductor is only 0.5 amperes. If no more than half of the conductors in each cable are current carrying, the allowable ampacity from the Table can be increased by a factor of 1.4 (0.5 X 1.4 = 0.7 amps).

The ampacity of a 60Â°C rated, 4-pair (8-conductor) No. 22 AWG CL2-LP cable is 0.7 ampere whenever 20 cables are bundled together. If only 4 of the conductors in each cable are current-carrying, then the allowable ampacity from the Table can be increased to 0.98 amperes (0.7A X 1.4 = 0.98A).

Limited Power Cable

A new type of cable identified as ***-LP*** ***(limited power)*** has been introduced; it is marked with the conductor ampacity immediately following the -LP designation on the jacket. For example, a cable may be marked ***24 AWG CL2-LP (0.5A)***. The ampacity of the conductors is never less than the ampacity marked on the cable jacket regardless of the number of cables that are bundled together. Where the ampacity shown in 725.144 for the number of cables in the bundle is greater than the ampere rating marked on the cable jacket, the higher rating can be used.

Question 97: The allowable ampacity for each conductor in a 4-pair, No.26 AWG, CL2 cable is 1 ampere. If only 4 conductors are current carrying, what is the allowable ampacity of each conductor?

A: 1 ampere.
B: 1.4 amperes.
C: 2 amperes.
D: 0.5 amperes.

Chapter 9, Annexes

Question 98: Chapter 9, Table 1, Note 9 Percent of Cross Section of Conduit and Tubing for Conductors and Cables.

Question ID#: 1247.0

An assembly of single insulated conductors without an overall covering is not considered a single cable when calculating conduit fill.

Table 1 Note 9 has been revised to make it clear that an assembly of single insulated conductors without an overall covering is not considered a single cable when determining conduit fill. Conduit fill ***"shall be calculated based upon the individual conductors."***

It is common today for a manufacturer to assemble a group of single conductors, twisted together, and cut to the length requested by the customer. The conductors are then delivered to the job site on a single reel. This has caused some inspectors to require conduit fill to be calculated based on the total cross-sectional area of the assembly as a single cable, rather than based upon the individual conductors.

For example, four 4/0 XHHW-2 single insulated conductors are twisted together on a single reel. According to the manufacturer, the cross-sectional area of one 4/0 XHHW-2 conductor is 0.3197 sq. in. The maximum outside diameter of the assembly is measured in the field at 1.55 in.

Based on the outside diameter of the assembly, the total area of the assembly as a single cable is calculated in the field by the inspector at 1.88 sq. in.

The total area of a single cable shall not exceed 53% of the cross-sectional area of a conduit. According to Chapter 9 Table 4, a 2 1/2 in. trade size EMT is required.

However Note 9 now clearly states that conduit fill shall be based upon the individual conductors. Total area of four single 4/0 conductors = 1.28 sq. in. (0.3197 X 4).

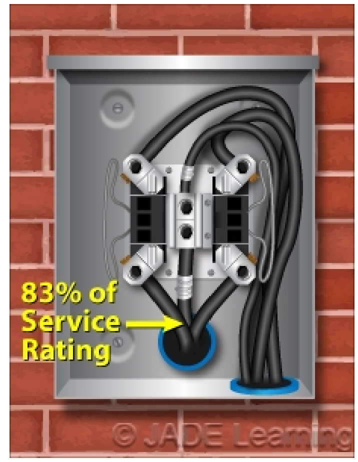
If more than two conductors are installed, the total area of the conductors shall not exceed 40% of the cross-sectional area of the conduit. According to the 40% column in Table 4, the size of the conduit can be reduced to 2 in. trade size EMT and still meet the code.

Question 98: Three 2/0 AWG single insulated conductors without an outer covering are twisted together on a single wire reel. The area of each conductor is 0.223 sq. in. What is the total area of the conductors for determining conduit fill?

A: 0.669 sq. in.
B: 0.223 sq. in.
C: 6/0 AWG.
D: 0.446 in.

Question 99: Informative Annex D Example D7 Sizing of Service Conductors for Dwelling(s).

Question ID#: 1248.0



A new table can be used to select conductor sizes for single phase dwelling services that carry the entire load of the dwelling.

Example D7 now includes a table that shows the permitted conductor size for dwelling unit service and feeder conductors. The conductor sizes in the table are based on 83% of the service rating as allowed by 310.15(B)(7).

For example, for a 200-amp dwelling service the conductor ampacity is:

200A X 83% = 166 amperes.

Use the 75o column in Table 310.15(B)(16) to find the conductor size.

A 2/0 AWG Cu or 4/0 AWG Al conductor is required.

The new table does the above math for single phase dwelling services rated up to 400 amperes. In order to use the table, the service or feeder conductors must carry the entire load of the dwelling unit. The table is based on 75oC terminations, an ambient temperature of 30oC, and not more than 3 current carrying conductors in a raceway or cable.

The temperature correction factors in Table 310.15(B)(2)(a) must be used if the ambient temperature is greater than 30oC (86oF). For example, XHHW-2 (90oC) conductors are installed in an attic with an ambient temperature of 36oC (96oF). The temperature correction factor is 0.91. To find the required ampacity, divide the required conductor ampacity by the correction factor. For a 200-amp service:

166 A Ã· 0.91 = 182.4 amperes

Use the 75oC column in Table 310.15(B)(16) to find the conductor size.

A 3/0 AWG Cu or 250 kcmil Al conductor is required.

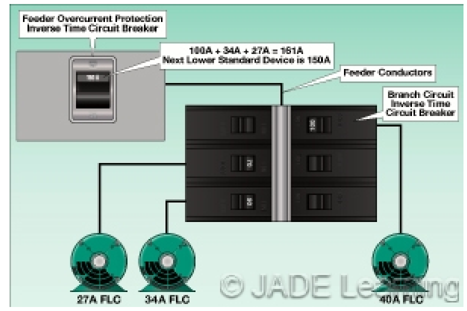
If there are more than 3 current carrying conductors in a raceway or cable the adjustment factors in Table 310.15(B)(3)(a) must also be applied.

Question 99: What is the minimum conductor ampacity for a 175 ampere dwelling service using 310.15(B)(7) without any other adjustment or correction factors?

A: 175 amperes.
B: 145.25 amperes.
C: 159.75 amperes.
D: 150 amperes.

Question 100: Informative Annex D Example D8 Motor Circuit Conductors, Overload Protection, and Short-Circuit and Ground-Fault Protection.

Question ID#: 1249.0



A new example of using an inverse time circuit breaker to protect a motor feeder is included in Annex D, Example D8.

Example D8 has been revised to include an example of a motor feeder protected by an inverse time circuit breaker. The rating of a feeder overcurrent device must be based on the specific type of device protecting the feeder. If the feeder is to be protected by a circuit breaker, the circuit breaker must not be rated more than the sum of the largest branch-circuit breaker plus the sum of the full load currents of the other motors supplied by the feeder. When sizing the feeder circuit breaker, rounding up to the next higher standard rating is not permitted. The first step is to determine the largest circuit breaker permitted for any of the individual motor branch circuits.

Example of Sizing a Feeder's OCPD

One 25-hp, 460-volt, 3-phase, AC squirrel cage motor

&

One 40-hp, 3-phase wound rotor motor are supplied by a motor feeder.

Overcurrent protection is an inverse time circuit breaker and is based on the full load current values in Table 430.250.

Branch circuit overcurrent device ratings are determined using section 430.52(C) and Table 430.52. Exception No. 1 to 430.52(C) allows the next higher standard rating to be used for the branch circuit overcurrent device.

25-hp squirrel cage motor FLC = ***34 amps.***

34A X 250% (from Table 430.52 for an inverse time circuit breaker) = 85A (***90A circuit breaker permitted***).

40-hp wound rotor motor FLC = ***52 amps.***

52A X 150% (from Table 430.52 for an inverse time circuit breaker used with a wound-rotor motor) = 78A (***80A circuit breaker permitted***).

The circuit breaker protecting the motor feeder is sized based on the largest branch circuit overcurrent device (90A circuit breaker in this case) plus the sum of the full load current (FLC) of all other motors (only one other motor in this case).

90A + 52A = 142 amps (A 125A circuit breaker is required because the feeder OCPD cannot go to the next standard size).

The rating of the feeder overcurrent device is not permitted to exceed 142 amps. The next lower standard rating for a circuit breaker is 125 amps

Question 100: There are three, 460-volt, 3-phase squirrel cage motors: Full Load Currents (FLC) are 14, 21, and 27 amps. The largest branch circuit breaker is 70A and it protects the 27-amp motor. What is the largest standard rating permitted for an inverse time circuit breaker protecting the MOTOR FEEDER?

A: 110A.
B: 100A.
C: 125A.
D: 150A.

Answer Sheet **Darken the correct answer. Sample: A ⬤ C D**

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9.) A B C D	29.) A B C D	49.) A B C D	69.) A B C D	89.) A B C D
10.) A B C D	30.) A B C D	50.) A B C D	70.) A B C D	90.) A B C D
11.) A B C D	31.) A B C D	51.) A B C D	71.) A B C D	91.) A B C D
12.) A B C D	32.) A B C D	52.) A B C D	72.) A B C D	92.) A B C D
13.) A B C D	33.) A B C D	53.) A B C D	73.) A B C D	93.) A B C D
14.) A B C D	34.) A B C D	54.) A B C D	74.) A B C D	94.) A B C D
15.) A B C D	35.) A B C D	55.) A B C D	75.) A B C D	95.) A B C D
16.) A B C D	36.) A B C D	56.) A B C D	76.) A B C D	96.) A B C D
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