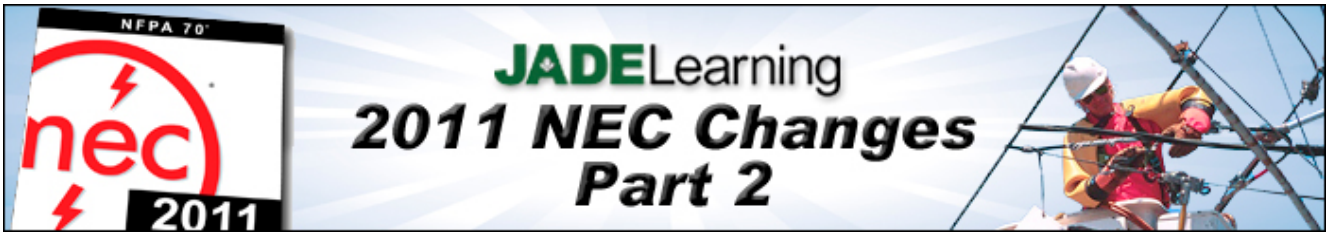



# 2011 NEC Changes Part 2 (Homestudy)

## California Electrical License

This course will review the second half of the most important National Electrical Code changes from the 2011 NEC. Changes in Articles 406.13 - Annex I will be covered.

**16 NEC Credit Hours $150.00**

This course is currently accepted by the Department of Industrial Relations.

Completion of this continuing education course will satisfy 16.000 credit hours of course credit type 'NEC' for Electrical license renewal in the state of California. Course credit type 'NEC'. Board issued approval date: 6/8/2016. Board issued expiration date: 1/1/2017.

JADELearning

# 2011 NEC Changes Part 2 (Homestudy) - CA

## Question 1: 406.13 Tamper-Resistant Receptacles in Guest Rooms and Guest Suites.

Question ID#: 126.0


***All non-locking type, 125-volt, 15- and 20-ampere receptacles in guest rooms and guest suites are required to be listed tamper-resistant receptacles.***

***All non-locking type, 125-volt, 15- and 20-ampere receptacles located in guest rooms and guest suites shall be listed tamper-resistant receptacles.***

Tamper-resistant receptacles protect young children from inserting metal objects into the openings of receptacles. Children often travel with their parents and spend the night in hotel rooms or suites and motels. The new requirement will guarantee that children in guest rooms and suites have the same protection from the electrical shock hazards of receptacles that they do at home.

A guest suite can be classified as a dwelling unit if it has permanent provisions for living, sleeping, cooking, and sanitation. As a dwelling unit, a guest suite would have required tamper-resistant receptacles under the 2008 NEC. Guest rooms generally do not have permanent provisions for cooking, but under the 2011 NEC all the non-locking, 125-volt, 15- and 20-ampere receptacles in a guest room are required to be tamper-resistant.

Question 1: In a guest room, where are tamper-resistant receptacles required?

A: In the living areas, but not in the bathroom.
B: In the bathroom only.
C: For the space heater, if over 125 volts and cord-and-plug connected.
D: In all areas if they are non-locking, 125-volt, 15- or 20- ampere receptacles.

## Question 2: 406.14 Tamper-Resistant Receptacles in Child Care Facilities.

Question ID#: 127.0

***All non-locking-type 125-volt, 15- and 20-ampere receptacles in child care facilities are required to be tamper-resistant.***

***In all child care facilities, all non-locking-type 125-volt, 15- and 20-ampere receptacles shall be listed tamper-resistant receptacles.***

This is a common sense change that extends the protection of tamper-resistant receptacles to child care facilities. Tamper-resistant receptacles are required in dwellings, guest rooms and guest suites, and in pediatric areas of health care facilities. They are now also required in child care facilities that are defined as a facility that provides services for more than four children that are age seven or younger.

Design documents for child care facilities place most receptacle outlets out of the reach of small children. However, with this change all non-locking, 125-V, 15- & 20-ampere receptacles in child care facilities are required to be tamper-resistant regardless of their location. Consumer Product Safety Commission reports indicate that approximately 2,400 children are injured each year when they put metal objects like hair-pins or paper clips in receptacle outlets. This change is particularly important in a child care facility because of the number of children in these locations. Tamper-resistant receptacles provide the best protection for children against electrical shock and burns.

Question 2: Which areas of a child care facility require 125-volt, 15- and 20-ampere receptacles to be tamper-resistant?

A: Only areas where receptacles are mounted within 24 inches of the floor.
B: All areas.
C: Play areas only.
D: Napping areas only.

## Question 3: 408.3(F) Support and Arrangement of Busbars and Conductors. Switchboard and Panelboard Identification.

Question ID#: 128.0


***Warning notices are required for switchboards and panelboards with high-leg system voltages and for ungrounded systems.***

Most switchboards and panelboards are supplied by single phase or 3-phase grounded systems which do not have a high-leg. Most high-leg systems operate at 240 volts, phase-to-phase. The voltage between the grounded conductor and two of the phases is 120 volts. The voltage between the grounded conductor and the high-leg is 208 volts.

If a switchboard or panelboard is supplied by a high-leg system, it must be identified with a legible and permanent marking to warn installers and maintenance personnel. Sections 110.15 and 230.56 have always required high-leg conductors to be identified with orange insulation or other orange marking.

Now, switchboards and panelboards with a high-leg are also required to be field marked with a notice that says, "Caution ____ Phase Has ____ Volts to Ground." Although most systems today are grounded, some are ungrounded. Switchboards and panelboards supplied by ungrounded systems are required to be field marked, "Caution: Ungrounded System Operating___ _____ Volts Between Conductors."

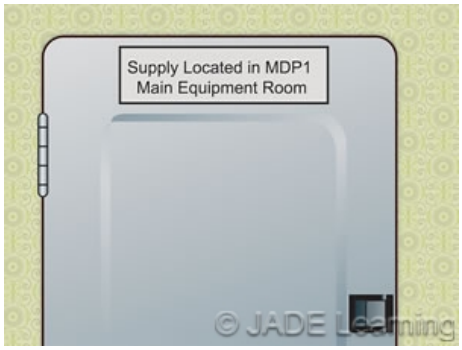
Extra caution is needed when working on ungrounded systems because if a ground fault goes undetected, a second ground fault creates a phase-to-phase fault.

Question 3: Which of the following is true about panelboards on an ungrounded system?

A: They are permitted in supervised industrial locations only.
B: They have a high-leg.
C: They must be marked to indicate the voltage between phases.
D: The equipment grounding conductor is permitted to be marked white.

## Question 4: 408.4(B) Field Identification Required. Source of Supply.

Question ID#: 129.0




***Except for 1- and 2-family dwellings, markings on switchboards and panelboards supplied by a feeder are required to show where the feeder originates.***

***All switchboards and panelboards supplied by a feeder in other than one- or two-family dwellings shall be marked to indicate the device or equipment where the power supply originates.***

In commercial and industrial locations there are many panelboards and switchboards located throughout the building. It can be difficult to find the circuit breaker or fused switch that supplies the feeder to a panelboard. In an emergency it is dangerous not to be able to locate and de-energize the source of power to a panelboard. When performing maintenance on a panelboard it is time consuming and frustrating to search for the power source in order to remove power from the panelboard. Identifying the source of power for panelboards and switchboards simplifies implementing lockout/tagout procedures when necessary for servicing electrical equipment.

The more detail that is included on the directory and/or sign, the more helpful it will be. The requirement says the "device or equipment" must be identified, so a general description of where the source is located is not good enough. A sign that said, "Panelboard supply located in Main Electrical Room" is not adequate. Likewise, identifying the supply circuit without including where the supply is located, "Panelboard supply fed from circuit breaker 20" is not helpful. A sign that said, "This panelboard fed from circuit 20 in Main Distribution Panel, 1st floor electrical room" would meet the requirements of this section and be an aid to troubleshooting and maintaining the switchboard or panelboard.

Question 4: If the following panelboards are supplied by feeders, which one is not required to be marked to indicate the device and location of the source of the power supplied to the panelboard?

A: A panelboard on the first floor of a multi-family dwelling.
B: A panelboard on the second floor of a three story single family dwelling.
C: A panelboard in an equipment room of a factory.
D: A panelboard in a restaurant.

## Question 5: 409.104(A) Industrial Control Panels. Wiring Space. General.

Question ID#: 130.0

Industrial control panels are not permitted to be used as junction boxes, raceways, or auxiliary gutters for conductors fed through or tapping off to overcurrent devices, equipment, or switches unless the conductor fill occupies less than 40% of the wiring space's cross-sectional area. The combined total cross-sectional area of conductors, splices, and taps in an industrial control panel are not permitted to fill more than 75% of any cross-sectional area of the wiring space.

It may have been convenient under the 2008 NEC to use the wiring space in an industrial control panel to connect to equipment like magnetic motor starters or mechanical relays that were located in other enclosures. This would have been OK because the 2008 NEC did not include equipment with switches and overcurrent device taps in the fill calculation. Now tap conductors that feed switches, overcurrent devices, and any type of equipment that is commonly found in industrial control panels, like terminal strips, variable frequency drives, or programmable controllers, are included in the 40% fill requirement.

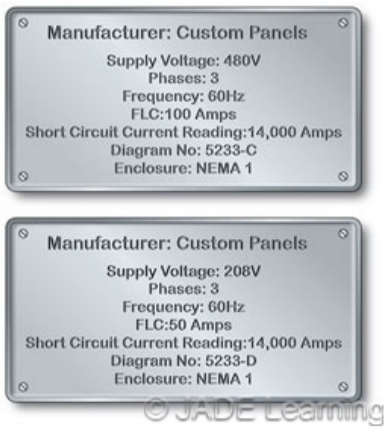
***There are maximum fill requirements in the wiring space of industrial control panels.***

Question 5: An industrial control panel has a wiring space with a cross-sectional area of 100 sq. in. What is the maximum amount of space that can be used for a single tap where the conductors feed another enclosure?

A: Less than 40 sq. in.
B: Less than 50 sq. in.
C: Less than 75 sq. in.
D: Less than 90 sq. in.

## Question 6: 409.110 Marking.

Question ID#: 131.0




***There are new marking requirements for Industrial Control panels.***

A new marking requirement has been added for industrial control panels. Presently, an industrial control panel must be marked with the manufacturer's name or trademark, the supply voltage, number of phases, frequency and full load current of each incoming supply circuit. Also, the short-circuit current rating of the industrial control panel, whether or not the panel is used as service equipment, the electrical wiring diagram number, and the enclosure type must be marked on the control panel.

The new requirement applies if there is more than one power source and more than one disconnecting means to disconnect the power sources. If it requires more than a single disconnect to remove power from the industrial control panel, then the control panel must be marked to indicate that more than one disconnecting means is required to de-energize the equipment.

Multiple sources of power in the same control panel is a serious hazard to personnel working on the equipment if it is not clear that multiple disconnects are required to remove all power. The new marking requirement will help electrical workers do their job safely.

Question 6: Which of the following signs clearly indicates that an industrial control panel has more than one source of power?

A: Supply voltage is rated 277/480 volts, 3-phase.
B: Supply voltage is rated 120/208 volts, 3-phase.
C: This panel has two incoming power sources.
D: Warning: Disconnect all power before working on this panel.

## Question 7: 410.16(C)(5) Luminaires in Clothes Closets. Luminaire Types Permitted.

Question ID#: 132.0

The way the NEC defines Closet Storage Space, it is not the entire closet. Luminaires can be installed in Closet Storage Space only if they are identified as suitable for installation within the Closet Storage Space.

Although the Closet Storage Space includes the area below clothes hanging rods, luminaires are generally installed in the upper part of a closet higher than the clothes hanging rod and higher than any shelves above the rod to provide better illumination for the entire closet.

As defined in 410.2, Closet Storage Space in the upper part of a closet is that portion of the closet that is more than 6-feet above the floor, or that is above the highest clothes hanging rod whichever is greater. The Closet Storage Space extends vertically above the rod or shelf up to the ceiling and is parallel to the back and side closet walls for 12-inches or the width of the shelf, whichever is greater.

LED luminaires are permitted in clothes closets and within the Closet Storage Space inside a closet. This is a clarification from 2008 that was being interpreted to mean LEDs were only permitted in the storage space of a clothes closet.

The LED luminaire can be installed in the Closet Storage Space if it is identified as suitable for installation within this space. A surface-mounted or recessed LED luminaire with a completely enclosed light source can also be installed in other locations within the clothes closet. If the LED luminaire is not within the closet storage space, it does not need special marking.


***LED luminaires are permitted in clothes closets and within the Closet Storage Space.***

Question 7: Which LED luminaire would require a marking to identify it as being suitable for installation within the closet storage space?

A: Surface-mounted above the closet door.
B: Recessed mounted in the middle of the closet, 36 inches from the closet storage space.
C: Surface-mounted on the ceiling of the closet above the clothes hanging rod, and within the closet storage space.
D: Recessed, in the wall opposite the clothes hanging rod.

## Question 8: 410.64 Luminaires as Raceways.

Question ID#: 133.0

***Under certain conditions luminaires are permitted to serve as raceways.***

In the 2008 NEC, section 410.64 said luminaires could not be used as a raceway unless they were listed and marked as a raceway. Then section 410.65 said luminaires could be connected end-to-end if connected together by a recognized raceway, and a 2-wire or multi-wire branch circuit could supply the luminaires in the string. It was confusing because one section required that luminaires be listed as a raceway and the next section basically said it was not necessary that luminaires be listed as a raceway but could be used as a raceway.

In the 2011 NEC this conflict was dealt with by deleting section 410.65 and including it in section 410.64. The NEC now permits luminaires to be used as a raceway if the installation complies with any of the following three conditions:

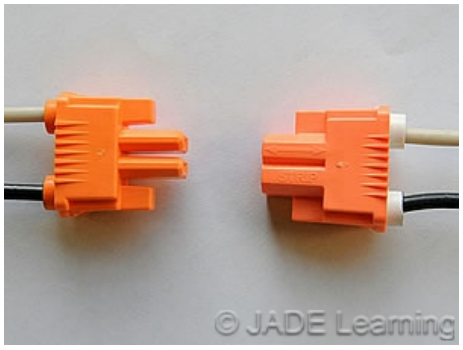
- they are listed for use as a raceway
- they are identified for through-wiring
- they are designed to be connected end-to-end to form a continuous lighting assembly or are individual luminaires connected together by a recognized wiring method. When connected together a single 2-wire branch circuit or a multi-wire branch circuit can be installed to supply the luminaires. If a luminaire is identified for through-wiring, other loads in addition to the luminaires, such as receptacles, can be supplied.

Question 8: Which of the following statements about luminaires connected as raceways is true?

A: Luminaires with a voltage of more than 150 volts to ground cannot be used as a raceway.
B: Luminaires can never be used for through wiring.
C: Only luminaires listed as a raceway can be used as a raceway.
D: Luminaires that are listed as a raceway can be used as a raceway and luminaires that are not listed as a raceway but are identified for through-wiring can be used as a raceway when connected by a wiring method permitted for the location.

## Question 9: 410.130(G) Special Provisions for Electric-Discharge Lighting Systems of 1000 Volts or Less. General. Disconnecting Means.

Question ID#: 134.0




***When ballasts are replaced, a means of disconnecting power is required to be installed for electric-discharge lighting systems of 1000 volts or less.***

***For existing installed luminaires without disconnecting means, at the time a ballast is replaced, a disconnecting means shall be installed.***

Unless exempted by the general requirement or by one of the 5 exceptions to section 410.130(G), in other than dwelling units, disconnecting means are required to be installed when replacing the ballast of fluorescent luminaires in indoor locations that use double-ended lamps. The disconnecting means can be either internal or external to the luminaire. When connected to a multiwire branch circuit, the disconnecting means must disconnect all the supply conductors to the ballast, including the grounded conductor.

The general rules apply to indoor locations not to luminaires installed outdoors. In addition there are 5 exceptions which are exempt from the rule requiring installation of a disconnect when replacing the ballast in an existing luminare. The 5 exceptions exempt the following from the general requirements:

- luminaires in hazardous locations
- luminaires for emergency illumination required in 700.16.
- cord-and-plug connected luminaires
- luminaires in industrial establishments with written procedures that guarantee restricted access and supervision ensures maintenance is performed by qualified personnel

- luminaires where two or more luminaires are supplied by other than a multiwire branch-circuit if the installation is designed so that the work space is illuminated when the circuit supplying the luminaire being serviced is turned off.

Unless exempted by section 410.130(G), when a fluorescent ballast is changed, a disconnecting means must be added. Most electricians have been changing ballasts with the power on, which can be a dangerous experience. Not only is there a shock hazard, but often when workers are shocked while changing a ballast they are injured when they fall off of a ladder.

Since the requirement to install disconnects for individual luminaires has only been enforced for two Code cycles, most of the fluorescent luminaires in use do not have disconnecting means. Installing a disconnect when the ballast is changed will begin the process of upgrading these older luminaires and making them safer to maintain.

Question 9: Unless excluded by the general requirement or by one of the five exceptions, when replacing a ballast in fluorescent luminaires that have double-ended lamps, disconnects are required to be installed for luminaires in which of the following locations?

A: In all hazardous locations.
B: Outdoors.
C: In a dwelling.
D: In an office which has only one luminaire and no other light source.

## Question 10: 422.15(C) Central Vacuum Outlet Assemblies.

Question ID#: 135.0

This section was revised to clarify that non-current-carrying metal components of central vacuum outlet assemblies are not required to be grounded unless they are likely to be energized. This change applies to listed systems controlled by low-voltage Class 2 circuits and also to listed systems incorporating a 120-V outlet in the central vacuum outlet-assembly.

***Metal parts of central vacuum cleaners that are not likely to become energized are not required to be grounded.***

Some inspectors were holding up final inspections by insisting that non-current carrying metal mounting screws and rivets in central vacuum outlet assemblies were required to be grounded. The language in the 2008 NEC supported this interpretation: "***Accessible non-current-carrying metal parts of the central vacuum outlet assembly shall be connected to an equipment grounding conductor."***

In the 2011 NEC, section 422.15(C) was revised as follows: "***Accessible non-current-carrying metal parts of the central vacuum outlet assembly likely to become energized shall be connected to an equipment grounding conductor in accordance with 250.110. Incidental metal parts such as screws or rivets installed into or on insulating material shall not be considered likely to become energized.***

Because mounting screws and rivets in outlets of central vacuum systems listed by Underwriters Labs (UL) are fastened to insulating, non-conductive material or are separated from electrical components by 1/2 inch of air, they are not likely to become energized.

Question 10: Which of the following statements best describes the grounding requirements for central vacuum outlet assemblies?

A: All accessible non-current-carrying metal parts are required to be connected to an equipment grounding conductor.
B: None of the accessible non-current-carrying metal parts are required to be connected to an equipment grounding conductor.
C: Accessible non-current-carrying metal parts that are likely to become energized are required to be connected to an equipment grounding conductor.
D: All mounting screws, springs, and rivets are required to be grounded.

## Question 11: 422.30 Disconnecting Means for Appliances.

Question ID#: 136.0

This change clarifies the requirement for disconnecting power from appliances. The 2008 NEC required only that a disconnecting means be provided for removing all ungrounded power for appliances. The 2008 requirement did not require the disconnect to simultaneously remove all power from the appliance.


***Disconnects are required to simultaneously remove all ungrounded conductors from appliances.***

This was seen as a potential safety hazard, and the 2011 NEC now requires that "***A means shall be provided to simultaneously disconnect each appliance from all ungrounded conductors in accordance with the following sections of Part III."***

Simultaneous removal of power from the appliance does not mean that separate disconnects supplying two or more branch circuits to the same appliance have to simultaneously remove power. However, disconnects for separate branch circuits supplying the same appliance are required to be grouped together and identified as the disconnect for the appliance.

For example, the disconnect for an appliance supplied by a single 240-V circuit is required to simultaneously remove both ungrounded conductors from the appliance. However, two disconnects for an appliance supplied by 2 branch circuits are not required to open simultaneously. For example, if an appliance is supplied by a 120-V branch circuit and a 240-V branch circuit, each disconnect is required to open the conductors it supplies simultaneously. The two disconnects are not required to open simultaneously; however, both disconnects are required to be grouped and identified as disconnects for the appliance.

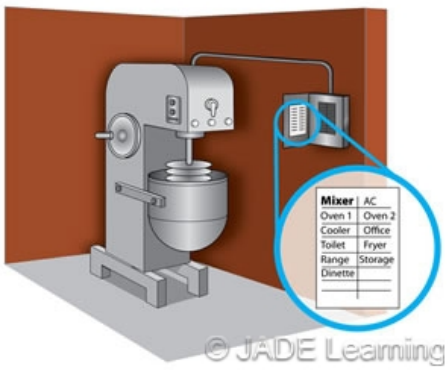
Question 11: If the disconnect is listed for the application and is correctly identified, which of the following does not comply with the requirement for disconnecting electrical power from an appliance?

A: A 120-V appliance supplied by a single pole, 120-V circuit breaker.
B: A 240-V appliance supplied by a double pole, 240-V circuit breaker.
C: A 240-V appliance supplied by a two pole, fusible disconnect.
D: An appliance supplied by a branch circuit from a subpanel located near the appliance and a panelboard located on another floor.

## Question 12: 422.31(C) Disconnection of Permanently Connected Appliances. Motor-Operated Appliances Rated Over 1/8 Horsepower.

Question ID#: 137.0

In the 2008 NEC, circuit breakers and branch-circuit switches were permitted to serve as the disconnecting means for permanently connected appliances only if they were in sight from the appliance or were capable of being locked.




***Under certain conditions an appliance disconnecting means is not required to be located within sight of the appliance.***

In the 2011 NEC, disconnects located within sight of permanently connected appliances are still required. However, an exception permits disconnects that are not located within sight of permanently connected appliances rated more than 1/8 HP. In order for the exception to apply the appliance must have a unit switch with a marked "off" position, and the appliance disconnecting means must be located according to 422.34 (A)(B)(C) or (D).

The location of the disconnecting means according to 422.34 depends on the type of occupancy: In a ***multifamily dwelling*** it is required to be within the dwelling unit or on the same floor as the dwelling unit. In a ***two-family dwelling*** it is permitted to be either inside or outside the dwelling unit where the appliance is installed. Section 422.34(C) specifically permits the service disconnect in a single-family dwelling to serve as the other disconnect required by 422.31(C). In ***other occupancies*** it is permitted to be a readily accessible branch-circuit switch or circuit breaker.

Appliances that have motors rated over 1/8 HP are capable of sudden movement

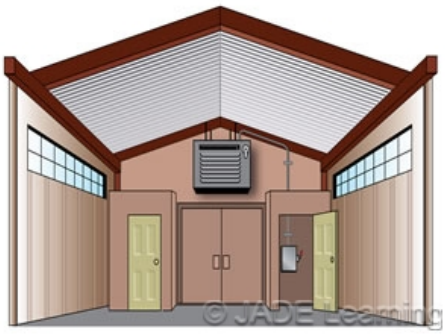
when power is applied. Clarifying the requirements for appliance disconnects provides an increased level of safety for personnel who service them.

Question 12: If a listed appliance has a unit switch with a marked "Off" position, which of the following disconnecting means is permitted if the appliance has a 1/4 horsepower motor?

A: A circuit breaker in a panelboard inside a dwelling unit if the motor it supplies is located inside a detached garage.
B: In a commercial occupancy, a listed motor-circuit breaker rated in horsepower installed in a panelboard that is not readily accessible to the tenant.
C: In a single-family dwelling, the service disconnect is used as the other disconnect.
D: In a multifamily dwelling on the 1<sup>st</sup> floor of a building, the other disconnecting means is on the 2<sup>nd</sup> floor.

## Question 13: 424.19(A) Fixed Electric Space-Heating Equipment. Disconnecting Means. Heating Equipment with Supplementary Overcurrent Protection.

Question ID#: 138.0




***Regardless of where they are located, disconnects for fixed electric space-heating equipment are required to be rated for 125% of the total connected load.***

Disconnects for fixed electric space-heating equipment are required to simultaneously open all ungrounded conductors and to be rated for 125% of the total load of the heater and motor.

The location of the required disconnect for a heater with a motor rated 1/8 HP or less is different than the location of a disconnect for a heater with a motor rated more than 1/8 HP.

The disconnect for a heater with a motor rated 1/8 HP or less must be within sight of the motor controller and heater or be capable of being locked in the open position.

The disconnect for a heater with a motor rated more than 1/8 HP must be within sight of the motor controller and heater and comply with Part IX of Article 430 which specifies type, ampere rating, and interrupting rating required for the disconnect. If there is a unit switch with a marked "off" position that disconnects all ungrounded conductors, the ***other*** disconnect can be out of sight of the heater if it is located per 422.34(A)(B)(C)(D), which deals with the disconnecting means for permanently connected appliances. See the commentary on section 422.31(C).

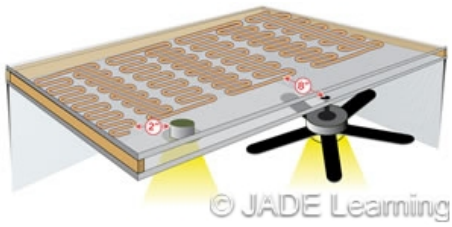
Question 13: If a listed fixed electric space-heater has a 1/4HP motor and a unit switch with a marked "Off" position, which of the following is permitted as its disconnecting means?

A: A readily accessible circuit breaker rated for 125% of the combined heater and motor load installed within sight from the heater.
B: A fused disconnect rated for 100% of the combined heater and motor load and located on the same floor as the heater.
C: The motor controller located on the heater.
D: A circuit breaker rated for 100% of the combined heater and motor load and located out of sight of the heater and motor controller.

## Question 14: 424.39 Heating Cables. Clearance of Wiring in Ceilings.

Question ID#: 139.0

The heating cables covered by this section are commonly installed in the ceiling of a room. In the 2011 NEC, heating cables are not permitted to be covered by any type of surface-mounted equipment.




***Equipment must maintain the required clearances for heating cables installed in ceilings.***

In addition to not allowing heating cable to be covered by equipment, the NEC requires a minimum clearance of 8 inches between heating cables and junction or outlet boxes used for surface-mounted luminaires. Recessed luminaires and their trim are required to have at least 2 inches of clearance from heating cables. A clearance of at least 2 inches is also required from openings for HVAC vents and similar opening in the surface in which heating cables are installed.

Because heating cables heat both the area above the cable and the room below it, wiring above a ceiling where heating cable is installed is required to be installed so that it is at least 2 inches above the heating cable. Because heat rises, wiring installed above a heating cable is required to have its ampacity corrected for an ambient temperature of 50Â°C (122Â°F).

Covering heating cables with surface-mounted equipment is prohibited because covering it could interfere with the cable's ability to direct heat into the room over which it is installed. This could cause excessive heat to buildup that could damage the heating cable itself and any wiring installed above it.

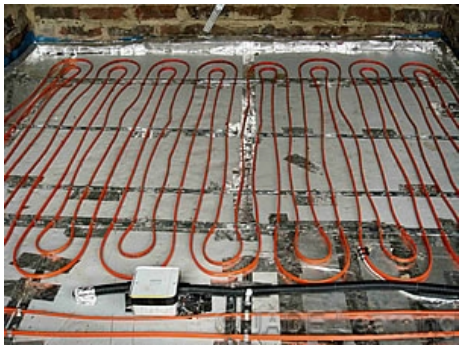
Question 14: Which of the following is a violation of the minimum clearances required for heating cable?

A: A heating cable installed within 4 inches of a recessed luminaire.
B: A circuit for a luminaire installed in an attic 3 inches above a heating cable.
C: A ceiling fan motor mounted so that the motor, housing, and trim covers a portion of the heating cable.
D: A heating cable installed within 31/2 inches of an opening for an HVAC vent.

## Question 15: 424.44(G) Heating Cables. Installation of Cables in Concrete or Poured Masonry Floors.

Question ID#: 140.0

Section 424.44(G) was revised to add kitchens to the areas requiring GFCI protection of heating cables installed in electrically heated floors. GFCI protection for receptacle outlets in kitchens, bathrooms, and areas where hydromassage tubs are installed has been required for a number of years because of the shock hazard potential when electricity is used in wet locations. Now GFCI protection is required for heating cables installed in concrete and poured masonry floors of kitchens, bathrooms, and areas where hydromassage tubs are installed.



***GFCI protection is now required for embedded heating cables installed in concrete and poured masonry kitchen floors.***

The floors of kitchens are often wet from spills and mopping. GFCI protection of embedded heating cables is needed for a wet kitchen floor just like it is needed for a wet bathroom floor or a wet floor near a hydromassage tub.

People in bathrooms and in areas where hydromassage tubs are installed are even more vulnerable to shock from a broken heating cable because they are not only wet, they are usually barefoot. Although there were no fatalities recorded, the Consumer Product Safety Commission reports indicate that some thermostats for electrically heated floor systems were recalled because of potential shock/electrocution hazards.

Requiring GFCI protection for heating cables in floors of kitchens, bathrooms, and areas where hydromassage tubs are used will reduce the likelihood of shocks caused by faulty or damaged heating cables and thermostats.

Question 15: Which of the following requires GFCI protection for heating cables?

A: A heating cable in a bathroom ceiling.
B: A heating cable installed in a poured concrete kitchen floor under ceramic tile.
C: A heating cable in the poured concrete floor of a greenhouse.
D: A heating cable in a wall where a hydromassage tub is installed.

## Question 16: 426.28 Fixed Outdoor Electric Deicing and Snow Melting Equipment. Ground-Fault Protection of Equipment (GFPE).

Question ID#: 141.0


***GFPE (Ground Fault Protection of Equipment) protection is now required for all fixed resistance type outdoor electric deicing and snow-melting equipment.***

This section was revised to require all types of resistance heating elements for deicing and snow melting to have ground-fault protection of equipment (GFPE) installed to disconnect ungrounded conductors in the event of a ground fault.

The 2008 NEC excluded mineral insulated resistive heating cable from the general requirement for ground-fault protection of equipment: ***"Ground-fault protection of equipment shall be provided for fixed outdoor electric deicing and snow-melting equipment, except for equipment that employs mineral-insulated, metal-sheathed cable embedded in a noncombustible medium."***

The 2011 NEC requires all types of resistance heating elements for deicing and snow melting to have ground-fault protection of equipment (GFPE).

Devices designed to provide ground-fault protection of equipment commonly have a trip level of 30-mA, plus or minus 15-mA. This means they may trip at as low as 15-mA or as high as 45-mA of ground fault current. These trip levels are much too high to protect people because at approximately 10-mA, adults lose the reflex ability to "let-go". Ground-fault protection of equipment (GFPE) devices are not designed to provide any protection for people; they only protect equipment. GFPE protection is not GFCI protection.

Question 16: Which of the following violates requirements for protecting embedded resistance heating cable listed for the installation?

A: A resistance heating cable is installed in a concrete sidewalk and provided with listed GFPE for the application.
B: A resistance heating cable employing type MI Cable is installed in a concrete sidewalk and provided with listed GFPE for the application.
C: A resistance heating cable is installed in a concrete sidewalk and is protected with a listed GFCI device.
D: A Mineral Insulated resistance heating cable is embedded in a concrete driveway and provided with listed GFPE for the application.

## Question 17: 430.6(D) Valve Actuator Motor Assemblies.

Question ID#: 142.0


***Calculating the required conductor ampacity and the overcurrent protection size for Valve Actuator Motor Assemblies is easier in the 2011 NEC.***

The 2011 NEC has made it easier to select the ampacity of conductors supplying Valve Actuator Motor Assemblies (VAM) and the branch-circuit short-circuit ground-fault protection for Valve Actuator Motor Assemblies. It is now clear that the nameplate full-load current is used to calculate conductor size and overcurrent protection size.

In the 2008 NEC there were no clear guidelines for selecting wire and fuse size for Valve Actuator Motor Assemblies. Some installers were using the locked-rotor current of the VAM to calculate the required ampacity of wires and overcurrent protection. The locked-rotor current is always higher than the running full-load current, and so conductors and fuses were being oversized.

Calculating branch circuit components for Valve Actuated Motor Assemblies is based on the full-load current nameplate rating on the assembly. For torque motors the calculation is based on locked-rotor current; for general motor applications the calculation is based on the Table values in Article 430; for alternating-current adjustable voltage motors the calculation is based on the maximum operating current marked on the motor or control nameplate. Selecting motor overloads is always based on the motor nameplate current rating.

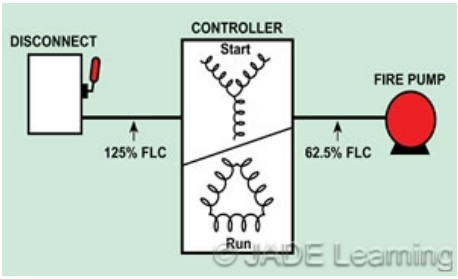
Question 17: Which of the following is used to determine the rating of the maximum branch-circuit short-circuit ground-fault protective device permitted for a Valve Actuator Motor (VAM)?

A: The horse power rating of the VAM.
B: The locked rotor current of the VAM.
C: The ampacity of the branch-circuit conductors supplying the VAM.
D: The VAM motor nameplate full-load current.

## Question 18: 430.22 Motor Circuit Conductors. Single Motor.

Question ID#: 143.0

Section 430.22 was rewritten to clarify the requirements for selecting the motor circuit conductors for single motors. The general rule requires a minimum ampacity of 125% of the motor's rated full-load current. The sub-sections under 430.22 were changed to make it more obvious when the 125% rule is to be applied.




***The requirements for motor circuit conductors for single motors have been clarified.***

In the 2008 NEC, the requirement for sizing conductors for a rectifier that supplied power to a DC-motor was stated in an exception. A rectifier changes AC voltage to DC voltage. In the 2011 NEC, the exception has been deleted, and the requirements are stated in positive language in 430.22(A). It requires conductors supplying power to a rectifier for a DC-motor to have an ampacity not less than 125% of the rectifier's rated input current. The minimum ampacity of field wiring between the rectifier and the motor is required to be not less than the following percentage of the motor's full-load current rating:

- 190% for single-phase, half-wave bridge rectifiers
- 150% for single-phase, full-wave bridge rectifiers

The requirements for motor circuit conductors for Wye-start, Delta run motors have been rewritten without changing the technical requirements. The minimum ampacity of conductors supplying the motor controller is required to be at least 125% of the motor's full-load current. However, the ampacity of conductors between the controller and the motor is required to be at least 62.5% of the motor's full-load current. This reduction in conductor size is permitted because of the operational characteristics of Wye-start, Delta-run motors.

Question 18: What is the minimum ampacity of conductors that supply AC power to a full-wave DC rectifier that supplies power to a single DC motor?

A: 100% of the rated input current of the rectifier.
B: 125% of the rated input current of the rectifier.
C: 150% of the rated input current of the rectifier.
D: 190% of the rated input current of the rectifier.

## Question 19: 430.22(G)(1) Conductors for Small Motors. 18 AWG Copper.

Question ID#: 144.0


***The NEC now includes a section covering conductors for small motors.***

Section 430.22(G) was added to cover conductors for small motors. Generally, the smallest motor circuit conductor is a No. 14 AWG copper conductor. However, 430.22(G)(1) permits No. 18 AWG copper conductors in a jacketed multiconductor cable or a flexible cord to be installed in a cabinet or enclosure if certain conditions are met:

- If the motor full-load current is over 3.5 amps and not over 5 amps, the overload protection must be a Class 10 (trips in 10 seconds at 600% of its rating).
- If the motor full-load current is less than 3.5 amps, the overload protection must be a Class 20 (trips in 20 seconds at 600% of its rating).
- Branch-circuit rated circuit-breakers are marked and listed for No. 18 AWG copper.
- Branch-circuit fuses are rated Class CC, Class J, or Class T and are listed for No. 18 AWG copper.
- Overcurrent protection is selected according to 430.52.

Question 19: When installed in a cabinet in compliance with Article 430, which of the following is the smallest motor circuit conductor permitted if the motor has a full-load current rating of 4 Amps?

A: A No. 14 AWG copper conductor in a jacketed multiconductor cable.
B: A No. 14 AWG copper conductor in a flexible cord.
C: A No. 18 AWG copper conductor in a jacketed multiconductor cable.
D: A No. 16 AWG copper conductor in a flexible cord.

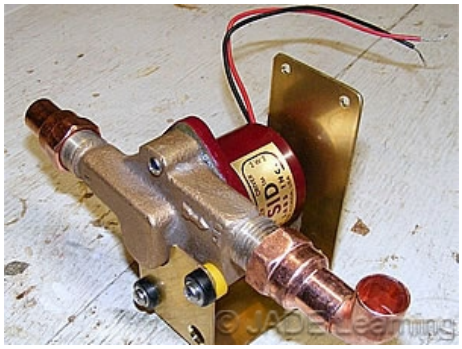
## Question 20: 430.22(G)(2) Conductors for Small Motors. 16 AWG Copper.

Question ID#: 145.0

The requirements for supplying small motors with No. 16 AWG copper conductors are similar to the requirements for supplying small motors with No. 18 AWG conductors.

Section 430.22(G)(2) permits a No. 16 AWG copper in a jacketed multiconductor cable or a flexible cord to be installed in a cabinet under the following conditions:

- If the motor full-load current is greater than 5.5 amperes and less than or equal to 8 amperes, the overload protection must be a Class 10 (trips in 10 seconds at 600% of its rating).
- If the motor full-load current is 5.5 amperes or less, the overload protection must be a Class 20 (trips in 20 seconds at 600% of its rating).
- Branch-circuit rated circuit-breakers are marked and listed for No. 16 AWG copper.
- Branch-circuit fuses are rated Class CC, Class J, or Class T and are listed for No. 16 AWG copper.
- Overcurrent protection is selected according to 430.52.



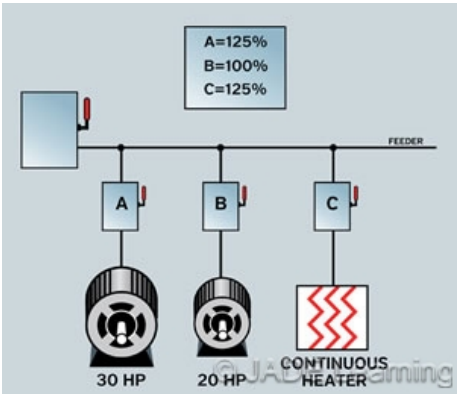

***Small motors are now permitted to be supplied with No. 16 & No. 18 AWG conductors.***

Question 20: When installed in a cabinet in compliance with Article 430, which of the following is the smallest motor circuit conductor permitted if the motor has a full-load current rating of 7 amps?

A: A No. 14 AWG copper conductor in a jacketed multiconductor cable.
B: A No. 14 AWG copper conductor in a flexible cord.
C: A No. 18 AWG copper conductor in a jacketed multiconductor cable.
D: A No. 16 AWG copper conductor in a flexible cord.

## Question 21: 430.24 Motor Circuit Conductors. Several Motor(s) and Other Load(s).

Question ID#: 146.0




***Rules for sizing conductors for several motors and other loads have been clarified.***

Section 430.24 was reorganized in a list format. The ampacity of conductors that supply several motors or that supply one or more motors and other load(s) is required to be not less than the sum of the following:

- 125% of the full-load current of the largest motor according to 430.6(A)
- The total of the full-load currents of any other motors in the group according to 430.6(A)
- 100% of any noncontinuous non-motor load(s)
- 125% of any continuous non-motor load(s)

The following is an example of the calculations required to determine the minimum ampacity of conductors supplying a group of motors and associated non-motor equipment that operates simultaneously. The loads consist of:

- One, 3-phase, 10-HP, 208-V squirrel-cage induction motor
- One, 3-phase, 20-HP, 208-V squirrel-cage induction motor
- One, 10-A noncontinuous, non-motor load

Use Table 430.250 to find the full-load current (FLC) of the motors.

- 20-HP motor = 59.4 amps; to increase its FLC by 25%: 59.4 X 1.25 = 74.25 amps.
- FLC for a 10-HP motor = 30.8 amps.

Load for 10 amp noncontinuous, non-motor load = 10 amps.

Total simultaneous load = 74.25 amps + 30.8 amps + 10 amps = 115.05 amps.
Round to 115 amps.
The minimum ampacity for the feeder is 115 amps.

There are three exceptions to the general rules:

- No. 1 covers short-time, intermittent duty motors.
- No. 2 covers fixed space-heating equipment with motors.
- No. 3 permits conductor ampacity to be based on simultaneous loads.

Question 21: What is the minimum ampacity of conductors supplying a group of four, 3-phase, 30-HP, 460-V squirrel-cage induction motors rated at 40 amps each that operate simultaneously?

A: 120 amps.
B: 140 amps.
C: 160 amps.
D: 170 amps.

## Question 22: 430.52(C)(7) Rating or Setting for Individual Motor Circuit. Motor Short-Circuit Protector.

Question ID#: 147.0

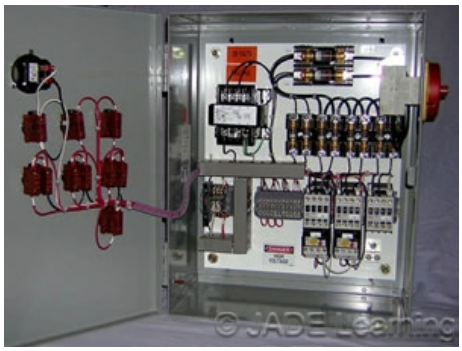
Section 430.52 identifies the sizes and types of motor branch-circuit short-circuit and ground-fault protective devices permitted for motors. Table 430.52 includes non-time delay fuses, dual element time delay fuses, instantaneous trip circuit breakers, and inverse time breakers. The Table does not include "motor short-circuit protectors."

Previous editions of the NEC did not define Motor Short-Circuit Protector, and some people incorrectly interpreted the term to mean an instantaneous trip circuit breaker. Now an Informational Note in the 2011 NEC indicates that: "***A motor short-circuit protector, as used in this section, is a fused device and is not an instantaneous trip circuit breaker."***

A Motor Short-Circuit Protector (MSCP) is permitted to be used in place of devices listed in Table 430.52 if it is a listed component of a combination motor controller with coordinated motor overload and short-circuit and ground-fault protection for all motor circuit conductors.

A MSCP is a fast acting device capable of removing power from a motor in the event of a short-circuit in 3 milliseconds (.003 second). Combination motor controllers incorporating motor short-circuit protectors (MSCPs) are required to open short-circuits exceeding 1300% of the full-load current of most squirrel-cage motors and to open short-circuits exceeding 1700% of the rated full-load current of design B energy-efficient motors.

MSCPs are designed to prevent motors from being damaged by short-circuits. They are not listed for use as branch circuit overcurrent protective devices.




***An instantaneous trip circuit breaker is not a MSCP (motor short-circuit protector), as defined in 430.52(C)(7).***

Question 22: Which of the following violates the requirements for using motor short-circuit protectors (MSCPs)?

A: A MSCP incorporated by the manufacturer in a listed combination motor controller for a DC motor.
B: A MSCP used as a branch circuit overcurrent protective device.
C: A MSCP incorporated by the manufacturer in a listed combination motor controller for a Design B energy efficient motor.
D: A MSCP incorporated by the manufacturer in a listed combination motor controller for a squirrel-cage induction motor.

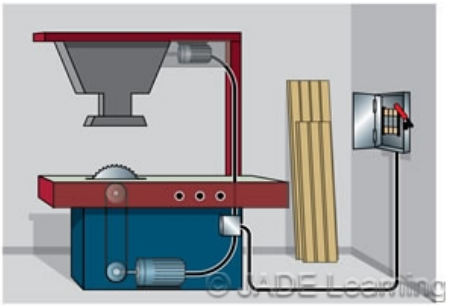
## Question 23: 430.53 Several Motors or Loads on One Branch Circuit.

Question ID#: 148.0

Section 430.53 permits a branch circuit to supply several motors or motors and other loads, and it also specifies the conditions under which this is permitted.

Prior to the 2011 NEC, the Code did not specify what types of overcurrent protective devices (OCPDs) could be used for branch circuits that supplied several motors. Now, the 2011 NEC specifies that ***"The branch circuit protective device shall be fuses or inverse time circuit breakers."***

This change prohibits the use of instantaneous protective devices like motor circuit protector (MCP) type circuit breakers and instantaneous trip circuit breakers because when used for branch circuits supplying several motors, their use makes it difficult to provide coordinated overcurrent protection. By requiring the use of inverse time circuit breakers or fuses for these circuits, this change eliminates that problem.




***Branch circuits supplying several motors are required to be protected by fuses or inverse time circuit breakers not instantaneous trip circuit breakers.***

Question 23: Which of the following is permitted as the branch-circuit short-circuit and ground-fault protective device for a branch circuit supplying a group of motors?

A: A listed motor short-circuit protector.
B: A listed single-pole inverse time circuit breaker.
C: A listed single-pole instantaneous trip circuit breaker.
D: A listed motor circuit protector (MCP) type circuit breaker.

## Question 24: 430.53(C) Other Group Installations.

Question ID#: 149.0

Some people confuse the terms ***overload protection*** with ***overcurrent protection.*** The terms may look and sound similar but their meanings are entirely different.

***Overload Protective Devices***: overload relays & heaters are designed to prevent motors from being damaged. Motor overload devices are commonly tripped by one of the following:

- bad bearings resulting from inadequate lubrication or harsh environment
- mechanical problems with the drive train between the motor and its load
- motor's load exceeding motor's HP rating
- phase loss and/or low voltage

***Overcurrent Protective Devices***: fuses and circuit-breakers are designed to remove power from conductors when a short circuit or a ground fault occurs. Their primary purpose is to remove power in order to prevent fire in the event of a short circuit or ground fault. They are not designed to provide motors with overload protection.

This section deals with devices permitted to provide ***overload protection*** for individual motors that are part of a group installation.

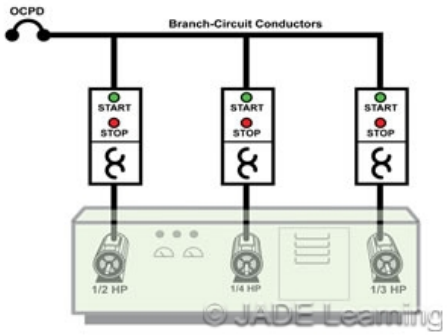
The 2011 NEC now permits overload devices that are not listed for group installations to provide overload protection for individual motors of a group installation that is supplied by a single branch circuit overcurrent protective device.

***Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices (not overload protection):***

Barring exceptions, in order for motor ***overload protection*** to be provided by devices that are not listed for group installations, the ***overcurrent device (not the overload device)*** protecting the motor in a group installation must comply with the following requirements from section 430.53(C):

- circuit breakers used must be listed inverse time breakers.
- fuses and inverse time breakers are sized in accord with 430.52 and cannot exceed the rating permitted for any individual motor overload device in the group.
- fuses and inverse time breakers are not to exceed the value permitted by 430.40 for overload relay of the smallest motor.
- non-motor loads are required to be protected as required by Parts I - VII of Article 240.

Note: The items listed above are ***overcurrent devices*** for motor conductor protection. This new code change does not remove the requirements for the motor to have ***overload protection*** which is usually provided by overload relays or bi-metallic strip heaters. The new code change basically allows motor overload devices that are not listed for use in group installations to protect motors that are installed as part of a group installation as long as the circuit conductors for the group installation have the correct ***overcurrent protection***.



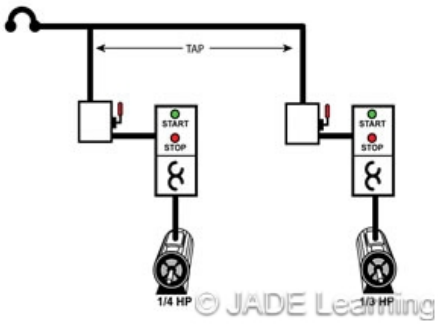

***Overload devices that are not listed for group installations are permitted to provide overload protection for individual motors in a group installation.***

Question 24: Which of the following is permitted to provide overload protection for a motor that is part of a group installation?

A: A listed nontime-delay fuse.
B: A listed single-pole inverse time circuit breaker.
C: A listed motor controller with a correctly sized overload relay.
D: A listed single-pole instantaneous trip circuit breaker.

## Question 25: 430.53(D)(3) Single Motor Taps.

Question ID#: 150.0




***The rules for tap conductors for single motors in group installations supplied by a single branch circuit have been clarified.***

Section 430.53(D) specifies the requirements for tap conductors for single motors in group installations supplied by a single branch circuit overcurrent protective device. The change now permits use of branch-circuit protective devices that are not identified for use with group installations.

Tap conductors are required to comply with one of the following requirements:

- The minimum ampacity of motor conductor taps must equal or exceed the ampacity of the branch circuit conductors.
- Motor circuit tap conductors are required to have an ampacity that is not less than 1/3 of the ampacity branch circuit conductors selected in accord with 430.22, and the conductors to the motor overload device are not permitted to be over 25 feet long and are required to be protected by a raceway or other approved means. For example, if the branch circuit rating was 60 amps, the minimum ampacity of the tap is 60/3 = 20 amps.
- The minimum ampacity of motor circuit tap conductors from the branch circuit overcurrent protective device to a listed manual motor controller marked "Suitable for Tap Conductor Protection in Group Installations" is required to be not less than 1/10 the ampacity of the branch circuit overcurrent protective device. For example, if the branch circuit rating was 100 amps, the minimum ampacity of the tap is 10 amps: 100/10 = 10 amps. This also requires conductors from the motor to the controller to be selected according to 430.22, to be protected by an enclosure or raceway, and to not exceed 10 feet in length.

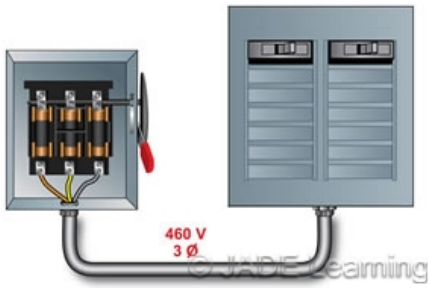
Question 25: For a single motor in a group installation, which of the following satisfies the requirements for tap conductors between the branch circuit overcurrent protective device and a motor controller?

A: A 30 foot tap installed in an approved raceway if tap conductors have 1/3 the ampacity of branch circuit conductors.
B: A 25 foot tap that is not enclosed in a raceway or protected by other approved means if tap conductors have 1/3 the ampacity of branch circuit conductors.
C: A 15 foot tap installed in an approved raceway if tap conductors have 1/10 the ampacity of branch circuit conductors.
D: A 25 foot tap installed in an approved raceway if tap conductors have 1/3 the ampacity of branch circuit conductors.

## Question 26: 430.63 Rating or Setting - Motor Load and Other Load(s).

Question ID#: 151.0

This section about selecting overcurrent protection for a feeder that supplies a motor and one or more other loads was rewritten. In the 2008 NEC the title to the section was ***Rating or Setting - Power and Lighting Loads***. The title in the 2011 NEC is more general and covers more than just lighting loads. Another change makes it clear that the overcurrent protection for the feeder cannot be smaller than the overcurrent protection required for the sum of the other loads, plus the rating of the overcurrent protection for the motor or hermetic refrigerant motor-compressor. All continuous duty loads on the feeder are to be calculated at 125% of their rated amperage.




***Overcurrent protection for a feeder is selected based on the rating of the motor and other connected loads.***

For example: Calculate the minimum overcurrent protection required for a 240-Volt feeder that supplies the following two loads:

- A 15-HP, continuous duty, 3-phase motor with nameplate current of 42-amps.
- A fixed electric heater with a nameplate current rating of 22-amps.

According to 430.22 the load on the feeder for a single continuous duty motor is 125% of the motor's ampacity as determined by the motor ampacity tables in Article 430. From table 430.250, the Full-Load-Current for a 230-V, 15-HP, 3-phase motor is 42-amps. The calculated load on the feeder for the motor is 52.5-ampers: (125% of the motor's rated amperage: 42-A X 1.25 = 52.5-A).

According to 424.3(B), fixed electric heaters are considered to be continuous loads. The calculated load on the feeder for the heater is 27.5-ampers: (125% of the heater's rated amperage: 22-A X 1.25 = 27.5-A).

The minimum size overcurrent for the feeder is 80-A: (27.5-A + 52.5-A = 80-A).

Question 26: What is the minimum overcurrent protection for a feeder that supplies both a continuous duty motor rated for 80 amps and a fixed electric heater rated at 100 amps?

A: 200 amps.
B: 205 amps.
C: 225 amps.
D: 250 amps.

## Question 27: 430.225(B)(1) Overload Protection. Type of Overload Device.

Question ID#: 152.0


***Not all motors require overload protection.***

Section 430.225 covers overload devices for motors rated over 600 volts. The general rule in 430.225(A) requires a motor circuit to have "***coordinated protection to automatically interrupt overload and fault currents in the motor, the motor-circuit conductors, and the motor control apparatus***."

If this were required in all locations, critical motors such as cooling pumps in nuclear reactors would automatically be shut down if the motor were overloaded. In some situations, having automatic safeguards to protect a motor from overheating just doesn't make sense.

The revised exception allows for such situations: "***Exception: Where a motor is critical to an operation and the motor should operate to failure if necessary to prevent a greater hazard to persons, the sensing device(s) shall be permitted to be connected to a supervised annunciator or alarm instead of interrupting the motor circuit."*** The change in the exception deleted the reference to motors in "***plants***" so that now the exception applies to critical motors regardless of their location.

Section 430.225(B)(1) was also revised to clarify the requirements for determining the settings for overload devices for motors operating at over 600 volts. The 2011 NEC requires that ***"Protective device settings for each motor circuit shall be determined under engineering supervision."*** This change means that settings for overload protective devices and short-circuit protection have to be analyzed under ***engineering supervision*** to ensure coordination of protective devices.

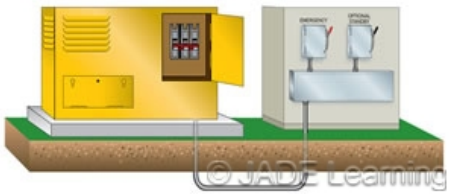
This change was needed because selecting short-circuit protective devices that are compatible with overload device settings for medium voltage motors is very complicated. Engineering supervision is required to ensure that the timing of the opening of short-circuit protective devices is synchronized with the opening of overload relays so that together the devices can interrupt the maximum available short-circuit current.

Question 27: Which of the following is not required to be determined under engineering supervision?

A: The settings for motor overload protective devices for 3-phase motors operated at 2300/4000 volts.
B: The settings for integral thermal protective devices for 3-phase motors operated at 2300/4000 volts.
C: The settings for motor overload protective devices for 3-phase motors operated at 460 volts.
D: The settings for external current-sensing overload protective devices for 3-phase motors operated at 2300/4000 volts.

## Question 28: 445.19 Generators Supplying Multiple Loads.

Question ID#: 153.0




***Generators must provide overcurrent protection in each ungrounded conductor for feeders supplying individual enclosures with overcurrent protection.***

Since 2008 a single generator has been permitted to supply more than one load. This allows a large generator to supply emergency systems, legally required standby systems, optional standby systems, fire pumps, or other backup loads. The feeder from the generator is connected to either (1) a vertical switchboard with separate sections, or (2) individual enclosures with overcurrent protection that are tapped from the generator feeder.

The 2011 NEC has added a requirement that if individual enclosures with overcurrent protection are tapped to the generator feeder, the generator itself must provide overcurrent protection in each ungrounded conductor of the generator feeder. Without this overcurrent protection at the generator, the feeder to the individual enclosures would not have overcurrent protection.

The change in 445.19(2) makes it clear that ungrounded feeder conductors supplied by a generator are required to have overcurrent protection at the generator if tap conductors are terminated in enclosures with overcurrent protection to supply different loads.

Question 28: If a feeder from a generator supplies multiple loads, as in the image above, which of the following statements is correct?

A: Overcurrent protection at the generator is not permitted.
B: Overcurrent protection at the generator is optional.
C: Taps for each of the multiple loads are permitted if the generator feeder has overcurrent protection at the generator.
D: The generator feeders are not permitted to be tapped.

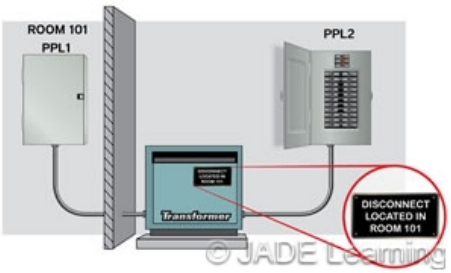
## Question 29: 450.14 Transformers. Disconnecting Means.

Question ID#: 154.0

This new section requires disconnects for all transformers, except Class 2 and Class 3 transformers. The transformer disconnect can be mounted within sight of the transformer or mounted remotely from the transformer. If the disconnect is remote from the transformer, it must be lockable, and the location of the disconnect must be field marked on the transformer.

A transformer primary can be supplied by a tap conductor, per 240.21(B)(3). Several transformers, or a transformer and other loads, can be supplied as taps from a single feeder. Before this new requirement for a transformer disconnect, there was no way to disconnect power from a transformer without disconnecting all the loads on the feeder. Now a transformer will have its own disconnect and the transformer can be de-energized without removing power from other loads.

The main reason for requiring a transformer disconnect is to protect the individual working on the transformer. Requiring the disconnect to be lockable if located remotely from the transformer and field marking the transformer with the location of the disconnect will add another layer of protection for electrical maintenance personnel.




***Disconnects are now required for transformers and the location of the disconnect must be marked on the transformer.***

Question 29: Which of the following is acceptable wording for the field marking on the transformer?

A: Transformer primary disconnect located in main floor equipment room, circuit 4, MDP 1.
B: Transformer secondary supplies PPL 23, located on mezzanine.
C: Transformer rated 225 kVA, 480 volts, 3-phase primary, 208 volts, 3-phase secondary.
D: Transformer supplied from PPL 203.

## Question 30: 500.2 Definitions. Combustible Dust.

Question ID#: 155.0

A Class II location is where fire or explosion hazards exist due to combustible dust. Prior to 2011, the NEC did not define what a combustible dust was. Section 500.2 now defines a combustible dust as:

***Any finely divided solid material that is 420 microns (.017 in.) or smaller in diameter (material passing a U.S. No. 40 Standard Sieve) and presents a fire or explosion hazard when dispersed and ignited in air. [NFPA 499, 200]***

The NEC does not classify areas. Areas are classified by engineers, operations and safety professionals and others who have experience with the processes and materials that will be used in an area. Once an area is classified it must be documented; the documentation must be made available to persons who are authorized to design, install, inspect, maintain, or operate electrical equipment at the facility.

How an area is classified makes a big difference in the type of equipment which is installed. There are three Classifications and two Divisions within each Classification.

- Class I locations are where fire or explosion hazards exist due to flammable gases or vapors, or flammable liquids.
- Class II locations contain combustible dust.
- Class III locations are where fire or explosion hazards exist due to ignitable fibers/flyings.

A Division 1 location is where ignitable concentrations of gas, dust, or fibers exist under normal conditions and/or during routine maintenance.


***There is now a definition for combustible dust.***

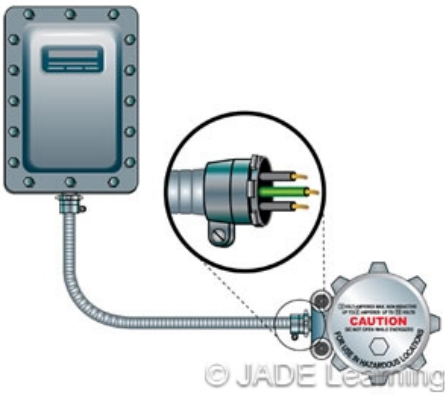
A Division 2 location is where gas, dust or fibers are present under abnormal conditions due to equipment failure or ruptured storage containers and similar abnormal conditions.

Question 30: If the following areas were classified as hazardous locations, which would be a Class II location?

A: The inside of a grain silo.
B: The processing areas of an oil refinery.
C: A warehouse where cotton bales are stored.
D: Above a vent pipe for propane gas.

## Question 31: 501.30(B) Types of Equipment Grounding Conductors.

Question ID#: 156.0




***When FMC or LFMC is installed in Class I locations, an equipment grounding conductor is required.***

In Class I locations, flexible metal conduit and liquidtight flexible metal conduit cannot be used as the sole ground-fault current path. This was true in the 2008 NEC, but it was not clear what ground-fault current path was required. Now, when these raceways are used, the general rule requires installation of a wire type equipment bonding jumper as the ground-fault current path. The required equipment bonding jumper is selected from Table 250.122 based on the size of the overcurrent device protecting the circuit. Section 250.102(E) permits the equipment bonding jumper to be installed in the raceway or externally.

An exception permits omitting the wire bonding jumper in Class I, Division 2 locations if three conditions are met:

- Listed liquidtight metal conduit is used in lengths of 6 ft. or less with listed grounding fittings.
- Maximum overcurrent protection for the circuit is 10 amperes.
- Circuit does not supply power equipment such as motors, luminaries, and heaters.

The 2011 NEC includes similar revisions when using flexible metal conduit and liquidtight flexible metal conduit in sections 501.30(B), 502.30(B), 503.30(B), 505.25(B), and 506.25(B).

Question 31: In a Class I, Division 2 location when is a wire equipment bonding jumper required?

A: With conductors installed in a 5 ft. run of liquidtight flexible metal conduit for a circuit protected at 10 amps supplying instrumentation.
B: With conductors installed in a 6 ft. run of liquidtight flexible metal conduit for a circuit protected at 5 amps supplying a digital readout.
C: With conductors installed in a 6 ft. run of liquidtight flexible metal conduit for a circuit protected at 10 amps supplying a meter.
D: With conductors installed in a 8 ft. run of liquidtight flexible metal conduit for a circuit protected at 15 amps supplying a pump.

## Question 32: 501.140(B)(4) Flexible Cords, Class I, Division 1 and 2.

Question ID#: 157.0

Flexible cords are permitted in Class I, Division 1 and Division 2 locations. Flexible cords can be used to connect temporary portable assemblies, portable lighting equipment, fixed or portable equipment that needs a range of movement, submersible pumps and electric mixers. These cords are required to be listed for extra-hard usage, to include an equipment grounding conductor, and to be supported in order to prevent tension on terminal connections.

In a Class I location that requires explosionproof equipment, the flexible cord can be terminated to the enclosure with a cord connector or attachment plug listed for the location. Another way to connect the cord is with a listed cord connector or attachment plug and a seal listed for a Class I location. In Division 2 locations, where explosionproof equipment is not required, a listed cord connector or attachment plug can be installed without a seal and without the connector having to be listed for a Class I, Division 2 location. In such areas, the cord connector has to be a listed product like other components covered by the NEC; but the connector does not have to be listed for a Class I, Division 2 location.


***Flexible cords are permitted in class I, Division 1 and 2 locations.***

The purpose of sealing raceways and installing flexible cord connectors listed for a hazardous location is to prevent explosive gases from migrating from the hazardous location to a non-hazardous area.

Question 32: In a Class I, Division 2 location where explosionproof equipment is not required, which of the following types of connections is required?

A: Connectors listed for a Class I, Division 2 location.
B: Connectors and seals listed for a Class I, Division 2 location.
C: Listed connectors.
D: Listed seals.

## Question 33: 502 Part III Equipment.

Question ID#: 158.0


***Equipment installed in Class II locations must be identified for the location.***

Part III covers equipment installed in Class II locations such as transformers, capacitors, switches, circuit breakers, motor controllers, fuses, motors and generators, luminaires, utilization equipment, flexible cords, receptacles and attachment plugs, signaling, alarm and remote-control and communications systems. The equipment itself, or the enclosure for the equipment, must be ***identified for the location.***

The phrase ***identified for the location*** was added to Part III to strengthen the requirements for equipment being installed in Class II locations. If equipment or equipment enclosures are identified for the location, they must be suitable for the specific purpose, function, use, or environment. In Article 100, an Informational Note explains that one way to tell if a product is ***identified*** for a particular installation is to determine whether or not it has been listed or labeled for that purpose. Listing or labeling by a qualified testing laboratory proves the equipment has been found to be suitable for use in the Class and Division locations for which it is identified.

Question 33: A motor installed in a Class II, Division 1 area is identified for the location. In this case, what does identified for the location mean?

A: It is listed or labeled for a Class II, Division 1 location.
B: It is listed or labeled for a Class II, Division 1 or 2 location.
C: It is listed for a Class I, Division 1 or 2 location.
D: It is listed or labeled for a Class I, Division 2 location.

## Question 34: 503.10(A) Wiring Methods. Class III, Division 1.

Question ID#: 159.0

A Class III, Division 1 area is a location in which easily ignitable fibers/flyings are handled, manufactured, or used. Some parts of textile mills, woodworking plants, and factories where clothing is manufactured are usually classified as Class III locations.

Class III locations are hazardous because easily ignitable fibers and combustible flyings are handled, manufactured, or used in these locations, but they are not likely to be in suspension in the air in quantities sufficient to produce ignitable or explosive concentrations.

The 2008 NEC permitted the following wiring methods in Class III, Division 1 locations: RMC, RNC, IMC, EMT, dusttight wire ways and MC & MI cable with listed fittings. The 2011 NEC expands this list to include PVC and Reinforced Thermosetting Resin Conduit (RTRC). Cable tray systems and cable tray wiring, such as Power Limited Tray Cable (PLTC) and Instrumentation Tray Cable (ITC) are permitted. Type MC, MI, or TC cable can be installed in cable tray in a single layer if spacing is maintained between the cables; however, an exception also permits Type MC cable listed for Class II, Division 1 locations to be used in Class III, Division 1 locations without spacing. For flexible connections, jacketed, interlocked armor Type MC cable with dusttight fittings is acceptable, as is liquidtight flexible metal conduit, liquidtight flexible non-metallic conduit and flexible cord.

***Additional types of wiring methods are now permitted in Class III, Division 1 locations.***

Question 34: Which of the following wiring methods is not permitted in a Class III, Division 1 location?

A: MC cable installed in a cable tray.
B: Electrical Non-metallic Tubing (ENT).
C: PVC conduit.
D: Rigid metal conduit.

## Question 35: 505.7(E) Simultaneous Presence of Flammable Gases and Combustible Dusts or Fibers/Flyings.

Question ID#: 160.0

Article 505, Zone 0, 1, and 2 locations, covers an alternate way to define hazardous areas that contain flammable gases, vapors, or liquids. Classification by zones is more popular in Europe than in the U. S., and imported equipment has Zone 0, 1, or 2 classification system markings.

Section 505.7(E) requires that the safe operating temperature of electrical equipment be considered when selecting wiring methods and equipment for areas where both flammable gases and combustible dust or fibers are simultaneously present. The area may be classified as a Class I, Zone 0, 1, or 2 location depending on the conditions.

All combustible vapors, fibers, and flyings have an ignition temperature. The equipment operating in the hazardous location must stay below the ignition temperature of the vapor, fibers or flyings. The operating temperature of equipment is marked on the equipment as a "T Code." Table 500.8(C) gives the maximum surface temperature for equipment marked with a T Code. Designers and installers should ensure that the surface temperature of equipment in such areas is less than the ignition temperature of fibers or flyings that may settle on it.

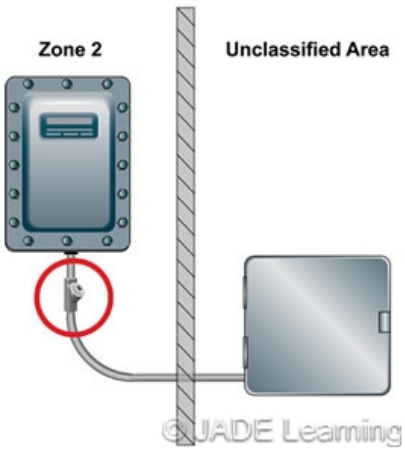

***New rules apply when flammable gases and combustible dusts are present in the same location.***

Question 35: Which of the following statements about areas that have both flammable gases and combustible dust or fibers present at the same time is true?

A: The area must be classified as a Class I, Division 1 location.
B: The area is classified to allow for the least flammable material.
C: The classification must consider all hazardous materials that are present as well as equipment operating temperature.
D: The operating temperature of the equipment can exceed the highest ignition temperature of the vapor, fibers or flyings present.

## Question 36: 505.16(C)(1)(b) Sealing and Drainage. Zone 2. Conduit Seals.

Question ID#: 161.0




***Seals are required to minimize the passage of gas or vapor when conduit passes from a Zone 2 area into an unclassified area.***

A Class I, Zone 2 area as defined in Article 505 will be like one of the four areas described in 505.5 (B)(3)(1,2,3, & 4):

- An area where under normal conditions combustible concentrations of flammable vapors or gases is unlikely.
- An area where closed systems and containers contain flammable gasses and liquids.
- An area where positive ventilation prevents combustible concentrations of flammable vapors or gases.
- An area adjacent to a Class I, Zone 1 location that could be contaminated by combustible concentrations of flammable vapors or gases unless this were prevented by positive ventilation provided with safeguards against ventilation system failure.

When conduit passes from a Zone 2 area into an unclassified area the conduit must be sealed to minimize the amount of gas or vapor that can pass into the unclassified area beyond the seal. The seal can be located on either side of the boundary between the Zone 2 area and the unclassified area, but it must be within 10 ft. of the boundary. The conduit between the sealing fitting and the point where the conduit leaves the Zone 2 area must be rigid metal conduit or intermediate metal conduit, without a coupling or fitting.

The conduit seal is not required to be flameproof or explosionproof, but it must be identified for the purpose of minimizing passage of gasses under normal conditions. The seal must be accessible.

Question 36: Which of the following installations is a violation of the requirements for sealing conduit leaving a Zone 2 area and passing into an unclassified location?

A: The seal is located in the unclassified area.
B: The seal is not explosionproof.
C: The seal is enclosed within a finished sheet-rock wall.
D: The conduit makes a 90 degree bend between the seal and the point where it leaves the Zone 2 area.

## Question 37: Table 514.3(B)(1) Class I Locations - Motor Fuel Dispensing Facilities.

Question ID#: 162.0

The Zone classification system has been added to Table 514.3(B)(1). The Table now defines hazardous locations around equipment in a motor fuel dispensing facility using the Class I, Division 1 or 2 method or the Zone 0, 1, or 2 method.

The revised Table is taken from the 2008 edition of NFPA 30A, Standard for Motor Fuel Dispensing Facilities and Repair Garages. Both the National Electrical Code and the NFPA 30A Code now use the same table.

Table 514.3(B)(1) in the 2011 NEC is similar to Table 514.3(B)(1) in the 2008 NEC, but there are some differences. The major difference is that in the 2011 NEC the Table includes a column identifying the Zone (Group IIA) for each location. Except for the inside volume of a fuel tank, every location which is a Division 1 is classified as a Zone 1 area. Every location which is a Division 2 is classified as a Zone 2 area. The inside volume of the tank is a Division 1 location, but classified as a Zone 0 area.

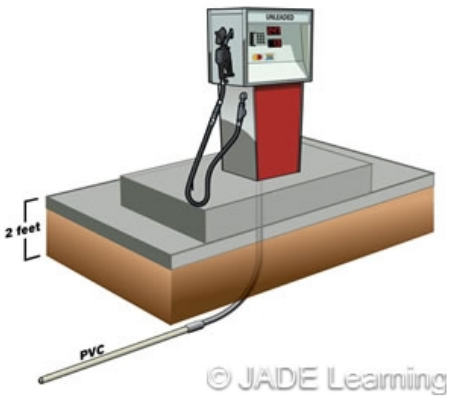

***Motor fuel dispensing areas now include the Zone classification system for hazardous locations.***

Question 37: Within 20 feet horizontally of an overhead type dispensing device enclosure, what is the Zone classification of the area from grade level to 18 inches above grade?

A: Zone 1.
B: Zone 2.
C: Zone 0.
D: Class I, Division 1.

## Question 38: 514.8 Ex. 2 Motor Fuel Dispensing Facilities. Underground Wiring.

Question ID#: 163.0




***The general term, Rigid Nonmetallic Conduit, has been eliminated from the NEC.***

Underground wiring below a Class I, Division 1 location or a Class I, Division 2 location, such as wiring feeding a fuel dispensing pump, is required to be rigid metal conduit or intermediate metal conduit. It must be sealed within 10 ft. of where it emerges from underground.

Exception No. 2 permits Type PVC and Type RTRC conduit below Class I, Division 1 locations or Class I, Division 2 locations if the conduit is buried under not less than 2 ft. of cover. If PVC or RTRC is used, the last 2 ft. of the installation up to the point where it emerges from grade must be rigid metal conduit or steel intermediate conduit.

The 2008 NEC used the term ***Rigid Nonmetallic Conduit*** where the 2011 NEC refers to PVC conduit or RTRC. Type HDPE conduit is another type of non-metallic conduit but it is not permitted for underground wiring to a gas pump. Type PVC conduit is covered in Article 352, Type RTRC conduit is covered in Article 355, and Type HDPE is covered in Article 353. These three conduits have different characteristics, and the 2011 NEC does not use the general term, ***Rigid Nonmetallic Conduit***.

Question 38: Which of the following statements about underground wiring below a Class I, Division 1 or 2 location at a motor fuel dispensing facility is true?

A: HDPE conduit is permitted but must be buried under at least 2-ft. of cover.
B: Rigid Nonmetallic Conduit is permitted but must be buried under at least 12-in. of cover.
C: PVC conduit is permitted but must be buried under at least 2-ft. of cover.
D: Schedule 40 PVC conduit is not permitted for underground wiring below a Class I, Division 1 or 2 location at a motor fuel dispensing facility.

## Question 39: 514.11 Circuit Disconnects.

Question ID#: 164.0


***An emergency stop button at a service station is required to disconnect all circuits to dispensers and pumps.***

An emergency stop button which disconnects the AC power to the gasoline pump at a service station is no longer the only disconnect required. All of the circuits, including AC and DC power, low voltage, voice and data communications, computer circuits, and video, running to the dispensing pump must have a simultaneous disconnecting means. In an emergency situation, if the dispensing device was damaged there could be gasoline all around the gasoline pump. A spark from any of these circuits could ignite the spilled gasoline. Now all these circuits must be able to be simultaneously disconnected from the gasoline pump.

The pump manufacturers do not usually supply illustrations of the installation of a disconnecting means for circuits other than the AC power circuit. However, now the switch or other device that controls the approved disconnecting means selected to remove power from all circuits must be clearly identified, readily accessible, and remotely located from the dispensing equipment. All conductors for power, data, voice, and video circuits, including any grounded conductors, leading to or passing through a dispensing device, must be simultaneously disconnected.

Question 39: Which of the following statements about circuit disconnects for motor fuel dispensing equipment is true?

A: The disconnecting means can be located adjacent to the dispensing equipment.
B: All disconnecting means shall be located inside the building.
C: All types of electrical circuits including voice and data communications, computer circuits, and video circuits as well as power circuits at the dispensing equipment must be simultaneously disconnected by a disconnecting means operated by a control device located remotely from fuel dispensers.
D: Circuits operating at less than 50 volts are not required to have a disconnecting means.

## Question 40: 517.13(B) Grounding of Receptacles and Fixed Electrical Equipment in Patient Care Areas. Insulated Equipment Grounding Conductor.

Question ID#: 165.0

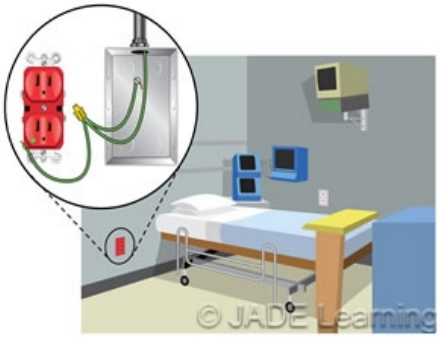
Section 517.13(B) was reorganized in a list format; it now specifies that the insulated copper grounding conductor in a branch circuit supplying a patient care area must be connected to:

- receptacle grounding terminals.
- metal enclosures and boxes containing receptacles.
- non-current carrying metal surfaces of fixed equipment operated at over 100 volts, if the surfaces touched by people are likely to become energized.

A new exception permits an insulated equipment bonding jumper to connect the box and receptacle to the insulated equipment grounding conductor. This requirement is part of the redundant "double" grounding required for patient care areas.

It is still necessary to install a separate insulated equipment grounding conductor back to the panel where the circuit originates.

The revisions to this section are a clarification, rather than a new requirement. Its purpose is to emphasize that the insulated equipment grounding conductor must be connected to the metal box and to the receptacle's grounding terminal. The exception specifically permits the practice of using equipment bonding jumpers sized according to section 250.122 to connect the grounding terminal of the receptacle to the metal box and to the insulated equipment grounding conductor.




***Equipment and devices in a patient care area must be connected to an insulated equipment grounding conductor.***

Question 40: In Patient Care Areas, which of the following practices is a Code violation?

A: Using an equipment bonding jumper to connect the insulated equipment grounding conductor to the receptacle.
B: Using an equipment bonding jumper to connect the metal box to the insulated equipment grounding conductor.
C: Using Table 250.122 to select the proper size equipment bonding jumper.
D: Using the grounded metal box as the sole means to ground the receptacle.

## Question 41: 517.16 Receptacles with Insulated Grounding Terminals.

Question ID#: 166.0


***Isolated Ground (IG) receptacles are not permitted in patient care areas.***

In patient care areas, r***eceptacles with insulated grounding terminals, as described in 250.146(D) shall not be permitted.*** This controversial change will eliminate Isolated Ground (IG) receptacles in patient care areas.

IG receptacles are used for sensitive electronic equipment to prevent electrical noise (electromagnetic interference), which can be present on the equipment grounding system, from interfering with the equipment.

The grounding terminal of IG receptacles is insulated from the metal box and the metal conduit system. The insulated equipment grounding conductor is connected directly to the grounding terminal of the receptacle. The mounting strap of the isolated receptacle is insulated from the receptacle's equipment grounding terminal.

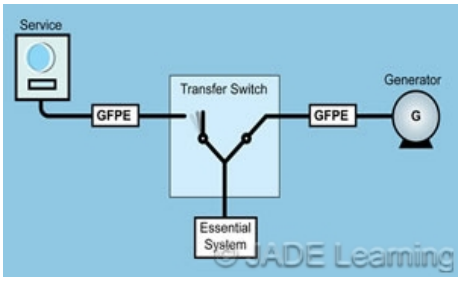
In patient care areas of health care facilities redundant grounding is required. The raceways and enclosures and the insulated equipment grounding conductor are all used as a ground-fault return path. If the IG receptacle is insulated from the raceway and enclosure, it compromises the redundant grounding required in patient care areas and increases the hazard to patient safety. Very small amounts of fault current can be fatal to a patient connected to medical equipment and instruments operating at 120 volts AC. An effective redundant grounding and bonding means minimizes these hazards.

Question 41: In health care facilities, where are isolated ground receptacles prohibited?

A: In data processing areas.
B: In patient care areas.
C: At nursing stations.
D: In facilities maintenance areas.

## Question 42: 517.17(B) Ground-Fault Protection. Feeders.

Question ID#: 167.0




***Ground-fault protection of equipment (GFPE) is permitted between a generator and the transfer switch.***

Ground fault protection of equipment (GFPE) is required for solidly grounded wye services with nominal voltages exceeding 150-V to ground and not exceeding 600-V phase-to-phase if the service is rated 1000 amps or more. In health care facilities, additional ground-fault protection is required in the next level feeder disconnecting means, downstream toward the load. Additional levels of ground-fault protection prevent a large ground-fault on a feeder supplied by a service from removing power from the whole facility by opening the service disconnect.

Ground-fault protection is permitted on the essential electrical system but cannot be installed on the load side of the transfer switch. The essential electrical system includes sources of alternate power and all connected distribution systems and equipment necessary to ensure electrical power to designated areas when normal power is disrupted.

In the 2008 NEC ground-fault protection of equipment was not permitted between the essential electrical system transfer switch and the generator. Since ground-fault protection could not be installed on the load side of the transfer switch, when the generator was supplying power to the essential electrical system there was no

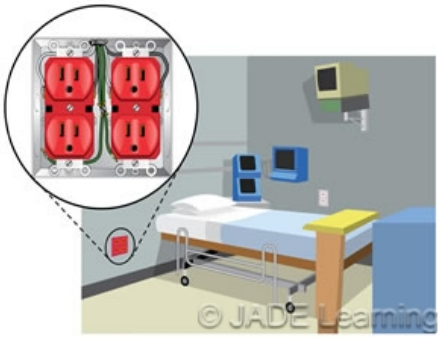
ground-fault protection for the essential electrical system. The 2011 NEC now permits ground-fault protection between the generator and the essential electrical system transfer switch(es).

Question 42: Which of the following statements about ground-fault protection in a health care facility is true?

A: All feeders must have ground-fault protection.
B: Ground-fault protection is permitted on the load side of the essential electrical system transfer switch.
C: Ground-fault protection is permitted on the line side of the essential electrical system transfer switch.
D: Ground-fault protection is always required for the essential electrical system.

## Question 43: 517.18(A) General Care Areas. Patient Bed Location.

Question ID#: 168.0




***Multiwire branch circuits are not permitted to supply patient bed locations.***

***The branch circuit serving patient bed locations shall not be part of a multiwire branch circuit.***

At least two branch circuits are required for the patient bed location in a general care area. The general rule requires one circuit to be supplied from the emergency system and the other by the normal system. All branch circuits supplied by the normal system are required to come from the same panelboard. A branch circuit supplying a patient bed location cannot be part of a multiwire branch circuit because handle-ties or multi-pole circuit breakers are required by 210.4 for multiwire branch circuits. If one circuit trips, the other circuits could trip, leaving other patient bed locations without power.

For example, what would happen if a 3 circuit multiwire branch circuit supplied power to a patient bed location in three different rooms? Monitoring or treatment equipment that is important for the patient's care is plugged into the patient bed location circuits. If one circuit trips, de-energizing this equipment, it is a serious problem. If all the circuits in a multiwire branch circuit trip, in three different patient bed locations, it can be a disaster.

A similar requirement prohibits multiwire branch circuits in patient bed locations in critical care areas.

There are three exceptions to the general rule:

- Permits normal circuits serving specialized equipment to originate in different panels.
- Exempts medical facilities like clinics and doctor's offices from the requirements in 517.18(A).
- Exempts patient bed locations in general care areas supplied by two transfer switches on the emergency system from having circuits supplied by the normal system.

Question 43: Which of the following violates the requirements for branch circuits for patient bed locations?

A: One branch circuit in a patient bed location general care area supplied by the normal system and another circuit supplied by the emergency system.
B: Two branch circuits supplying a patient bed location.
C: A multiwire branch circuit supplying a patient bed location in a hospital.
D: All branch circuits from the normal system shall originate in the same panelboard.

## Question 44: 517.18(B) General Care Areas. Patient Bed Location Receptacles.

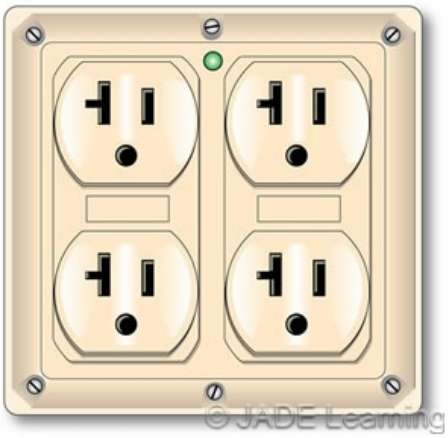
Question ID#: 169.0

Each patient bed location must be supplied with four receptacles. The receptacles can be single receptacles, duplex receptacles, quadruplex receptacles or any combination of these three types. They must all be listed hospital grade receptacles and connected to the insulated equipment grounding conductor.

In the 2008 NEC, quadruplex receptacles were not permitted. A duplex receptacle is counted as two receptacles and a quadruplex receptacle is counted as four receptacles.

Quadruplex receptacles are manufactured with four sets of contacts mounted on the same yoke. During a remodel, a quadruplex device could replace a duplex receptacle and double the number of receptacles at the patient bed location. In new construction, two branch circuits must be run to each patient bed location. Using quadruplex receptacles there can be a total of eight receptacles at each patient bed location.

Quadruplex receptacles are also permitted at patient bed locations in critical care areas.




***Quadruplex receptacles are now permitted at patient bed locations.***

Question 44: Which of the following statements about patient bed location receptacles is true?

A: Four hospital grade receptacles are required for each general care patient bed location.
B: Eight hospital grade receptacles are required at each general care patient bed location.
C: Quadruplex receptacles are not permitted in patient bed locations.
D: Non-grounding quadruplex receptacles are required in patient bed locations

## Question 45: 517.63(A) Grounded Power Systems in Anesthetizing Locations. Battery-Powered Lighting Units.

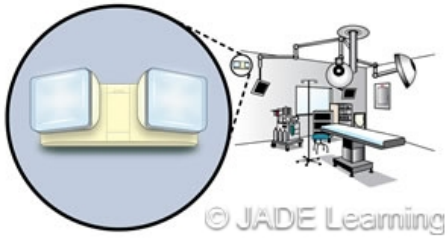
Question ID#: 170.0

A battery powered lighting unit is individual unit equipment for backup illumination.

The 2008 NEC required the battery powered lighting units in surgical suites, or other locations where patients were under anesthesia, to be connected to the normal source of power. If the normal source of power failed, the battery powered lights would come on immediately and stay on for 90 minutes as required by most fire codes, or until they were discharged, or until the normal power was restored.

In a surgical suite the lighting has two sources of power. The critical branch is powered by the emergency generator and would turn the lights on in the surgical suite within 10 seconds after the normal power failed. With the battery powered lighting units connected to the normal source of power, they would continue to burn, even though the critical branch was powering the luminaires in the surgical suite.

The 2011 NEC permits the battery powered lighting units to be connected to the critical power branch provided they are connected ahead of any local switch. When the normal power fails the battery powered lights are turned on until the transfer switch connects the surgical suite lighting to the critical branch powered by the generator. When the normal lighting is being powered by the critical branch, the battery powered lighting units are turned off and recharged. This is better because if the critical power should also fail, there will be 90 minutes of light from the fully charged battery powered lighting units.



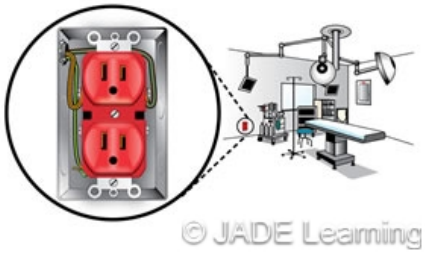

***In anesthetizing locations battery powered lighting units are required.***

Question 45: Which of the following statements about lighting in an anesthetizing location is correct?

A: Battery powered lighting units are not required, provided the normal lighting is backed-up by the emergency system.
B: One battery powered lighting unit is required; it is permitted to be wired to the critical lighting circuit for the area provided it is connected ahead of any local switch.
C: At least two battery powered lighting units are required in the area.
D: One battery powered lighting unit is required; it is required to be wired to the critical lighting circuit for the area and controlled by a local switch.

## Question 46: 517.160(A)(5) Isolated Power Systems. Installations. Conductor Identification.

Question ID#: 171.0




***Conductors of isolated power systems must be identified differently from other conductors.***

An Isolated Power System as defined in 517.2 is ***"A system comprising an isolating transformer or its equivalent, a line isolation monitor, and its ungrounded circuit conductors."*** Because there are ***no grounded conductors*** in circuits originating from Isolated Power Systems, conductors of isolated power systems must be identified differently from other conductors. Isolated conductor No. 1 must be orange with at least one distinctive stripe along its entire length. Isolated conductor No. 2 must be brown with at least one distinctive stripe along its entire length. For 3-phase systems, isolated conductor No. 3 must be yellow with at least one distinctive stripe along its entire length.

The wording in the 2008 NEC allowed the isolated conductors to be taped at the terminations with a distinctive color. In 2011 a conductor used on an isolated system must be manufactured with a stripe (other than white, green or gray) along its entire length. When the isolated circuit supplies 125-volt, single-phase, 15- and 20-ampere receptacles, ***the striped orange conductor is connected to the terminal on the receptacles identified for a grounded conductor even though it is technically an ungrounded conductor***.

Isolated power systems are supplied by isolation transformers, or their equivalent, and are ungrounded. Isolated circuits are used to supply operating rooms and other areas where even small ground fault currents can be fatal. Isolated circuits have a line isolation monitor that indicates the total hazard current. A green signal lamp indicates the system is isolated from ground. A red signal lamp indicates the hazard current to ground is above 5 mA.

Question 46: A 125-volt, 20-ampere receptacle in an operating room is supplied by an Isolated Power Circuit. Excluding equipment grounding conductors, how many grounded conductors are connected to the receptacle?

A: 1.
B: 2.
C: 3.
D: 0.

## Question 47: 518.3(B) Assembly Occupancies. Other Articles. Temporary Wiring.

Question ID#: 172.0

In exhibition halls used for trade shows, worship, entertainment, eating, drinking and similar purposes temporary wiring, installed per Article 590, is permitted to be installed to the trade show booths; however, the ground-fault requirements in 590.6 do not apply. Although, in general, ground-fault protection for personnel is not required for the temporary wiring in these locations, the 2011 NEC requires ground-fault protection where other sections of the NEC would normally require it. For example, at a trade show for kitchen interiors, an energized countertop receptacle would need to be GFCI protected. At a garden show an energized receptacle within 6 ft. of a sink would have to be GFCI protected. At a swimming pool and spa trade show, if a pool was filled with water a receptacle within 20 ft. must be GFCI protected.

***The requirements for GFCI protection for temporary wiring in assembly occupancies have been clarified.***

Where GFCI protection is provided by a cord and plug connection to a feeder or branch circuit, the cord-set must be listed as "portable GFCI protection", or it must have the equivalent GFCI protection. Ground-fault protection for portable use is different than permanently installed GFCI protected receptacles. A listed, portable GFCI receptacle or portable GFCI protected cord-set will shut down if the polarity of the grounded and ungrounded conductors is reversed. On permanently installed GFCI receptacles the outlet will still be energized if the grounded and ungrounded conductors were reversed. A cord-set made-up in the field using a permanent type GFCI receptacle does not provide the equivalent protection of a listed, portable GFCI cord-set.

Question 47: Which of the following is a true statement about temporary wiring at a trade show?

A: All the wiring in the display booths must be GFCI protected.
B: Extra-hard usage flexible cords are permitted to be laid on the floor where they are accessible to the public.
C: A listed, portable GFCI protected cord set is permitted to supply temporary power.
D: GFCI protection for all receptacle outlets is required if the outlet is accessible to the public.

## Question 48: 520.44 Borders, Proscenium Sidelights, Drop Boxes, and Connector Strips.

Question ID#: 173.0


***Grounded conductors and equipment grounding conductors in cords used for stage lighting and equipment can be re-identified.***

In theaters, motion picture and television studios a border light is a permanently installed overhead strip. A proscenium is the wall and arch that separates the stage from the auditorium. A drop box is a box containing pendant- or flush-mounted receptacles attached to a multiconductor cable via a strain relief or multipole contactor. A connector strip is a metal wireway containing pendant or flush receptacles.

Cords and cables for supply to border lights, drop boxes and connector strips are required to be listed for extra-hard usage. A new section at 520.44(C)(3) allows conductors in multiconductor extra-hard usage cords and cables to be re-identified as grounded conductors by a distinctive white marking at the terminations. Conductors can be re-identified as equipment grounding conductors by a distinctive green marking at the terminations.

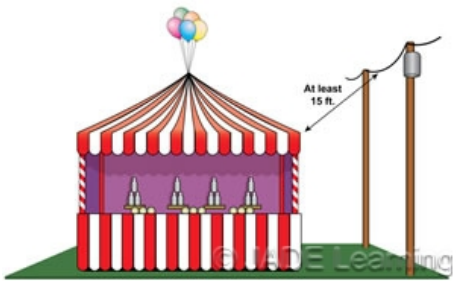
In Article 200 grounded conductors in sizes No. 6 AWG and smaller must have a continuous white or gray outer finish. Likewise in Article 250, insulated No. 6 AWG and smaller equipment grounding conductors must be green or green with a yellow stripe. This is not required in Article 520 for grounded conductors and equipment grounding conductors in multiconductor extra-hard usage cords and cables. Conductors of any color can be re-identified at their terminations as grounded or equipment grounding conductors.

Question 48: A 21 conductor extra-hard usage cord is used to connect a drop box. Which of the following statements is true?

A: Only the conductors with insulation which is white or gray may be used as grounded conductors.
B: Only the conductors with insulation which is green or green with a yellow stripe can be used as equipment grounding conductors.
C: Only conductors larger than No. 6 AWG can be re-identified at their terminations as grounded conductors or equipment grounding conductors.
D: A conductor of any color can be re-identified as a grounded conductor by using white tape at each end.

## Question 49: 525.5(B)(2) Carnivals, Circuses, Fairs, and Similar Events. Overhead Conductor Clearances. Clearance to Portable Structures. Over 600 Volts.

Question ID#: 174.0




***A 15-ft. clearance is required between overhead conductors rated over 600 volts and portable structures at carnivals, circuses, fairs and similar events. The 15-ft, clearance is measured horizontally and extends vertically to grade.***

At fairs, carnivals, circuses, and similar events portable structures and amusements are not permitted to be located under or within 15 feet horizontally of overhead conductors operated at over 600 volts. The 15 foot dimension extends on each side of the conductors vertically from the conductor's height to grade level.

For example, for a 2400 volt power line that is 24 feet above grade, portable structures are not permitted to be placed under or within 15 feet horizontally of either side of the line; from grade level up to the power line (24 feet) there is a 30 foot wide space centered under the power line in which no portable structures are permitted.

Keeping portable structures well away from conductors operating at over 600 volts will help protect contractors and carnival or fair employees from contacting the high voltage lines when they are setting up the booth, ride or structure. It will also protect customers by ensuring that amusements like Ferris wheels and merry-go-rounds are not near overhead conductors.

Question 49: Which of the following installations at a traveling fair is a 2011 NEC Code violation?

A: A 10 ft. tall concession stand located directly underneath overhead conductors operating at 2400 volts.
B: An 8 ft. tall ticket booth located 20 ft. horizontally away from high voltage conductors.
C: A Ferris wheel that is 25 ft. horizontally from overhead conductors operating at 1000 volts.
D: A circus tent located 50 ft. horizontally from overhead high voltage conductors.

## Question 50: 547.5(G) Agricultural Buildings. Wiring Methods. Receptacles.

Question ID#: 175.0


***Areas that require GFCI protection in agricultural buildings for 125-volt, single-phase, 15 and 20-ampere devices have been expanded.***

In agricultural buildings, all 125-volt, single-phase, 15 and 20-ampere devices located in an area with an equipotential plane, outdoors, in a damp or wet location, or in a dirt confinement area for livestock are required to be GFCI protected.

The 2008 NEC did not require GFCI protection for accessible receptacles serving dedicated loads, provided that a GFCI protected receptacle was located within 3 ft. of the non-GFCI receptacle. The 2011 NEC deleted this permission. Now, a receptacle outlet that supplies a dedicated piece of equipment, such as an automatic feeder, must be GFCI protected if the receptacle is located in an area requiring GFCI protection.

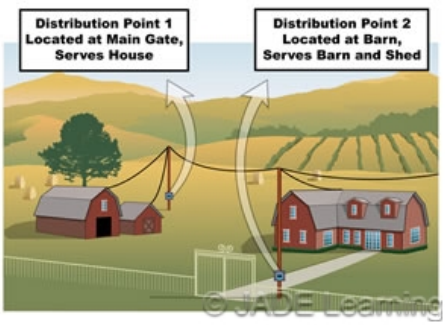
Older farm equipment has leakage currents high enough to trip a GFCI device. Newer farm equipment, which is built according to current product standards, has much less leakage current and will not cause nuisance tripping of GFCI devices. Even though there is a great deal of older farm equipment still in service, the NFPA Code panel did not want non-GFCI protected receptacles in areas where there is an increased shock hazard.

Question 50: In an agricultural building, where is a 125-volt, 15- or 20-ampere receptacle required to be GFCI protected?

A: In a dry, hay storage loft.
B: In an animal wash down area.
C: In a room with a wooden floor where saddles and feed are stored.
D: In the office ceiling for plug-in luminaires.

## Question 51: 547.9(D) Electrical Supply to Building(s) or Structure(s) from a Distribution Point. Identification.

Question ID#: 176.0




***The arrows in the drawing point to the close up view of the label on each service. In this drawing, Distribution Point No. 2 is located near the barn. Distribution Point No. 1 is located near the main gate. On farm properties, a plaque at each distribution point is required to indicate the location and structures supplied by other distribution points.***

People sometimes confuse the purpose of the plaque or notice required by 547.9(D) with the purpose of the circuit directory required by 408.4(A). They have very different purposes!

The question below is based on this illustration which represents a farm that has two distribution points supplied by a single service. The two plaques required by 547.9(D) do not serve the same purpose as a circuit directory required by 408.4(A). The required plaques are represented by the white notes in the drawing.

Basically, the plaques are there to tell someone where other distribution points are located on the property and what they supply.

There are two purposes for these plaques:

- to indicate the location of the other distribution points on the property and to identify the loads these other distribution points supply.
- to warn service personnel that there is more than one source of power for various buildings and structures on the property.

Distribution Point Number 1 is located near the main gate leading to the house. The information on the plaque located at ***Distribution Point Number 1*** should ***indicate the location of Distribution Point Number 2*** and the buildings or structures distribution point Number 2 serves.

Distribution Point Number 2 is located near a shed close to the barn. At ***Distribution Point Number 2*** a plaque should indicate ***the location of Distribution Point Number 1*** and what buildings or structures distribution point number 1

supplies.

The circuit directory required by 408.4 (A) on panelboards supplied by a distribution point is required to indicate what loads are supplied by each branch circuit and feeder originating in the panelboard supplied by that distribution point.

Question 51: Refer to the above illustration to answer this question.

A farm has two distribution points:

Distribution point No. 1 supplies the house and is located on a pole near the main gate.

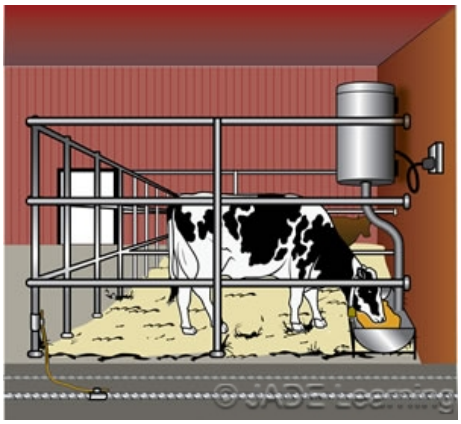
Distribution point No. 2 supplies the barn and a small shed; it is located on a pole near the barn and the shed.

Which of the following statements includes all information required to be on the plaque at distribution point #1 near the main gate?

A: Distribution Point No. 1 is located near the main gate.
B: Distribution Point No. 2 is located near the shed by the barn.
C: Distribution Point No. 1 is located near the main gate and it supplies the main house.
D: Distribution Point No. 2 is located to the right of the shed near barn; it supplies the barn and the shed.

## Question 52: 547.10(B) Equipotential Planes and Bonding of Equipotential Planes. Bonding.

Question ID#: 177.0



***The purpose of an equipotential plane is to minimize voltage differences between conductive surfaces.***

In areas where livestock can come in contact with metal equipment that might become energized, an equipotential plane is required. The goal of the equipotential plane is to keep voltage differences between conductive surfaces to a minimum. Voltage differences cause current flow. Current passing through an animal's body can harm or kill the animal, and animals shocked by very brief, small currents can behave unpredictably, often harming themselves or harming farm workers.

Equipotential planes are required indoors in confinement areas with concrete floors where an animal may contact metal equipment or structures. An equipotential plane is required outdoors in an area where the livestock stand close to metallic equipment that may become energized.

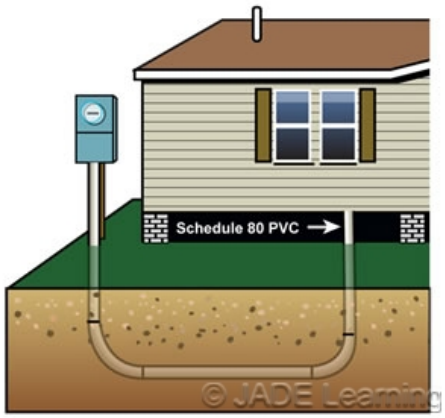
The bonding jumpers used to connect metallic equipment to the equipotential plane must be solid copper. The 2008 NEC did not require a solid conductor. A solid bonding conductor will withstand the harsh conditions in a livestock confinement area and will be less likely to be affected by corrosion. The bonding conductor can be insulated, covered or bare, and not smaller than No. 8 AWG.

Question 52: Which of the following conductors is suitable as a bonding jumper for an equipotential plane in an agricultural building?

A: A No. 10 AWG solid copper conductor.
B: A No. 6 AWG insulated, solid copper conductor.
C: A No. 6 AWG insulated, stranded copper conductor.
D: A No. 3 AWG stranded aluminum conductor.

## Question 53: 550.15(H) Mobile Homes, Manufactured Homes, and Mobile Home Parks. Wiring Methods and Materials. Under-Chassis Wiring (Exposed to Weather).

Question ID#: 178.0




***Schedule 80 PVC is now permitted to be installed exposed under mobile homes and manufactured homes to connect to the manufacturer's PVC.***

Mobile home manufacturers install PVC conduit extending from the panelboard inside the home to the underside of the home for the purpose of attaching the feeder conduit.

The general rule in the 2011 NEC requires field installed wiring that is exposed to moisture and/or physical damage under these homes to be protected by RMC or IMC; however, now the 2011 NEC permits Schedule 80 PVC or RTRC listed for exposure to physical damage to connect to the manufacturer's PVC, when the Schedule 80 PVC or RTRC rises vertically from a burial depth of at least 18 inches.

Most jurisdictions were accepting this wiring method in earlier Code cycles. However, some AHJs would not allow Schedule 80 PVC conduit to connect to the manufacturer's conduit because the field installed feeder conduit was not closely routed against the frame of the mobile home. An exception in the 2008 NEC permitted Type MI cable, EMT and PVC conduit to be used for under chassis wiring, but only if it was closely routed against the frame of the mobile home; these wiring methods are still permitted under the 2011 NEC.

The new wording in the 2011 Code clearly permits Schedule 80 PVC or RTRC to connect to the mobile home conduit under a mobile home chassis where the wiring is exposed to moisture and physical damage.

Question 53: Which raceway is not permitted for under-chassis wiring on a mobile home, where the wiring is exposed to moisture and physical damage?

A: Intermediate Metal Conduit.
B: Flexible Non-metallic Tubing.
C: Electrical Metallic Tubing.
D: Schedule 80 PVC Conduit.

## Question 54: 550.25 Arc-Fault Circuit-Interrupter Protection. Mobile and Manufactured Homes.

Question ID#: 179.0


***AFCI protection is required in the same locations in a mobile or manufactured home as in a site built home.***

AFCI protection is required in the same locations in a mobile or manufactured home as in a site built home. In mobile and manufactured homes all 120-volt branch circuits that supply 15- and 20-ampere outlets in family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways and similar rooms require AFCI protection.

Fires in a mobile or manufactured home kill people at twice the rate of fires in other one- and two-family dwellings. Fires caused by malfunctions in the electrical systems of mobile and manufactured homes are a leading cause of these fires. The wiring in mobile homes is subject to damage that permanent structures are not subjected to when these structures are being moved.

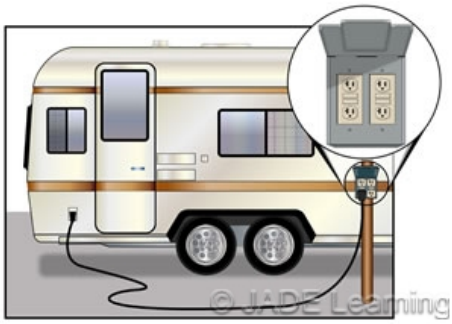
AFCI protection of living areas will give the residents of mobile homes and manufactured homes the same protection that residents of site built homes are provided.

Question 54: In a mobile home, which circuits do not require AFCI protection?

A: Lighting in the living room.
B: Receptacle outlets in the bedroom.
C: Kitchen countertop receptacles.
D: Lighting in a clothes closet.

## Question 55: 552.59(A) Park Trailers. Outdoor Outlets, Fixtures, Including Luminaires, Air-Cooling Equipment, and So On. Listed for Outdoor Use.

Question ID#: 180.0




***Requirements for luminaires, equipment and GFCI protection have been clarified for park trailers.***

Fixtures, luminaires, and equipment for a park trailer that is installed outside the park trailer is required to be listed for outdoor use. Outdoor receptacle outlets on park trailers must meet the requirements of 406.9(A) and (B). The receptacle outlets must be listed weather-resistant types and suitable for damp or wet locations. In wet locations, 15- and 20-ampere, 125- and 250-volt receptacles must have an enclosure that is weatherproof whether or not the attachment plug is inserted.

A park trailer is defined as "***A unit that is built on a single-chassis mounted on wheels and has gross-trailer area not exceeding 400 sq. ft. in the set-up mode."*** A park trailer is different from a recreational vehicle, which is defined in Article 551 as temporary living quarters for recreational, camping or travel use, which either has its own motive power or is mounted on or drawn by another vehicle. Examples of recreational vehicles are travel trailer, camping trailer, truck camper and motor home.

Although park trailers and recreational vehicles are not permanent residences, both Article 551 and Article 552 have requirements similar to dwelling units for receptacle placement, GFCI protection and outdoor receptacles.

Question 55: When installed for use at a park trailer which of the following is required to be listed for outdoor use?

A: A luminaire installed beside the front door outside the park trailer.
B: Circuit breakers installed in a park trailer.
C: Switches installed in a park trailer.
D: Receptacles installed in a park trailer.

## Question 56: 555.3 Marinas and Boatyards. Ground-Fault Protection.

Question ID#: 181.0


***Two different types of ground-fault protection are permitted for marinas and boat yards.***

The NEC allows ground-fault protection for marinas and boat yards to be provided in two different ways:

- The main overcurrent device for the supply to a marina is permitted to provide ground-fault protection not exceeding 100 mA.
- Each feeder or branch circuit can be individually provided with ground-fault protection not greater than 100 mA.

Marinas can be dangerous places. Receptacles providing shore power for boats are rated 30 amps, 50 amps, 60 amps or 100 amps. Ground-faults onboard vessels and boats connected to these receptacles or cuts and breaks in the shore power cords can be a serious shock hazard. Ground-fault protection for branch circuits supplying the docks can help prevent electrical shock injuries.

However, because the "let-go" current level for adults is approximately 10 mA, a ground-fault device at the marina service set for 100 mA does not provide the same level of protection as a GFCI circuit breaker or receptacle with a trip setting of 4 mA-6 mA. Also, the leakage current from a large marina may exceed the 100 mA setting at the main overcurrent device without leakage current at an individual branch circuit in the marina being greater than 6 mA. If this was the case, power to the entire marina would be cut off.

Question 56: Which of the following is a requirement for ground-fault protection at a marina?

A: Ground-fault protection provided at the main disconnect can not be greater than 100 mA.
B: All the 15- and 20-ampere receptacles are required to be the ground-fault circuit- interrupter type.
C: Branch circuits supplying boat slips must be GFCI protected. Other branch circuits in the marina are not required to be GFCI protected.
D: Each feeder in the marina must have ground-fault circuit-interrupter protection not greater than 6 mA.

## Question 57: Table 555.12 Marinas and Boatyards. Load Calculations for Service and Feeder Conductors. Demand Factors.

Question ID#: 182.0


***The demand factors for service and feeder calculations for marinas and boatyards have been clarified.***

Table 555.12 is used to calculate the demand factors for receptacles installed for shore power in marinas and boatyards. The demand factors increase as the number of receptacles increase.

The left hand heading of the Table in the 2008 NEC was labeled ***Number of Receptacles.*** The heading in the 2011 NEC is labeled ***Number of Shore Power Receptacles.*** The demand factors now clearly only apply to the receptacles installed for shore power at the marina slips and not to convenience receptacles installed at other locations. If all receptacles, including shore power receptacles and convenience receptacles, are added together, the inflated demand factors could cause the service and feeder conductors to be too small.

***Refer to Table 555.12 in the NEC:*** If a marina has 100, 20 amp receptacles used for shore power the demand factor from Table 555.12 is 30% of the sum of the rating of the receptacles. The sum of the ratings of the shore power receptacles is 2000 amps (100 x 20 amps). Apply the 30% demand factor and the feeder to the marina shore power receptacles is 600 amps (2000 amps x 30% = 600 amps). The demand factor varies depending on the amount of receptacles installed for shore power.

Question 57: Refer to Table 555.12 in the NEC. A marina has 35, 20 amp shore power receptacles and 15, 20 amp convenience receptacles. What is the calculated load on the feeder for the shore power receptacles?

A: 500 amps.
B: 420 amps.
C: 360 amps.
D: 280 amps.

## Question 58: 555.13(B)(4) Wiring Methods. Installation. Portable Power Cables.

Question ID#: 183.0


***Listed marine power outlets with terminal blocks are now permitted instead of a junction box on each floating section.***

Marina docks and piers can be constructed of floating sections connected together. The 2008 NEC required a junction box at each floating section with permanently installed terminal blocks so that the wiring to each section could be easily disconnected.

A new statement has been added to the 2011 NEC which permits a listed marine power outlet with terminal blocks to be used instead of a junction box. The junction box was unnecessary because modern marine pedestal power centers have permanently installed terminal blocks, and the feeder to the pedestal can be disconnected just as easily as it could be if the terminal blocks were in a junction box. The requirement to install a junction box meant an additional point of connection that was subject to corrosion and a possible point of failure for the wiring system.

Question 58: Which of the following statements about marina wiring is true?

A: Marine power pedestals are not permitted on floating docks.
B: A feeder to a section of floating dock must terminate in a junction box.
C: Junction boxes on floating docks are prohibited.
D: A feeder to a section of floating dock can terminate in a marine power pedestal.

## Question 59: 590.4(D) Temporary Installations. General. Receptacles.

Question ID#: 184.0


***Extra duty weather-resistant covers and weather-resistant receptacles are now required for pole/post mounted receptacles on construction sites.***

Receptacle outlets installed as temporary power in wet locations are often subject to abuse. Temporary power receptacles on construction sites are often exposed to damage from people and equipment. A new section has been added which requires that 15- and 20-ampere, 125- and 250-volt receptacles installed for temporary power in wet locations in an enclosure mounted on a post, similar structure, or that are supported by conduit as described in 314.23(B or F), have a cover or ***outlet box hood*** which is identified for ***extra duty***, per 406.9(B)(1).

The standard bubble cover used at dwelling units is not built to withstand the rough treatment of construction sites or other temporary wiring locations. The ***extra duty*** outlet box hood or cover is much stronger and more durable than plastic in-use, bubble covers. If a 15- and 20-ampere, 125- and 250-volt receptacle is used for temporary power in a wet location, and is mounted on a pole, or mounted directly on grade and supported by raceways with threaded conduit entries, the cover or hood must be identified as ***extra duty.*** The receptacle must be listed weather- resistant type.

Question 59: Which of the following statements about receptacles installed at temporary installations is true?

A: In a wet location, enclosures for 30-ampere receptacles must have a cover identified as extra duty.
B: All receptacles used for temporary installations must be listed weather resistant.
C: In a wet location, in an enclosure supported from grade, the outlet box hood or cover for an enclosure for a 20-ampere, 250-volt, twist-lock receptacle must be identified as extra duty.
D: In a wet location, enclosures for 15- and 20-ampere, 125- and 250-volt receptacles must be metal.

## Question 60: 590.6 Ground-Fault Protection for Personnel.

Question ID#: 185.0


***GFCI protection is required for 15-30 amp, 125/250-volt receptacle outlets on generators rated 15 kW or less used for temporary power.***

The 2011 NEC requires portable generators used for temporary power that were manufactured after January 1, 2011 to include GFCI protection for all 125-volt and 125/250 volt, single-phase, 15-, 20-and 30-ampere receptacle outlets that are a part of the generator. If the generator will be used in wet or damp locations they are required to have in-use covers as required by 406.9(A & B).

Generators manufactured prior to January 1, 2011, were not required to include GFCI protection. Listed cord-sets that incorporate ground-fault protection for personnel are permitted to provide the required GFCI protection on 15 kW or less portable generators manufactured before January 1, 2011.

Requiring GFCI protected receptacles to be installed when the generator is manufactured will protect homeowners who buy portable generators and are unaware of the need for GFCI protection in temporary installations. GFCI protection at the portable generator will also protect workers on construction sites by protecting the branch circuit or feeder wiring from the generator to temporary receptacle outlets.

This entire section in the 2011 NEC on ground-fault protection for personnel at temporary installations has been rewritten to make it clear that GFCI protection for personnel is required for receptacle outlets that are not part of permanent wiring, and it is required for receptacle outlets that are existing or installed as permanent wiring.

Question 60: If a 15 kW single-phase portable generator that will be used for temporary power was manufactured on March 20<sup>th</sup>, 2011 which of the following statements is correct?

A: A listed cord-set with built-in GFCI protection is acceptable instead of GFCI protected receptacles on the generator.
B: Receptacles rated 125-volt and 125/250 volt, single-phase, 15-, 20- and 30-ampere must have GFCI protection.
C: In-use covers for 15- and 20- ampere, 125-volt receptacles are not required regardless of where the generator is used.
D: A receptacle rated 50 amperes, 250 volts must have GFCI protection.

## Question 61: 600.1 Scope.

Question ID#: 186.0


***Article 600 applies to the field wiring of signs as well as to the installation of conductors and equipment, regardless of voltage.***

***<u>This article covers the installation of conductors, equipment, and field wiring for electric signs and outline lighting, regardless of voltage.</u>***

Electric signs are manufactured to operate on many different voltages. There are low voltage electric sign circuits classified as Class 2 circuits and high voltage signs operating at up to 15,000 volts. The phrase, ***<u>regardless of voltage,</u>*** has been added to the scope of Article 600 to make it clear there is no single voltage range for electric signs. Also, new wording makes it clearer that Article 600 applies to the field wiring of signs as well as the installation of conductors and equipment.

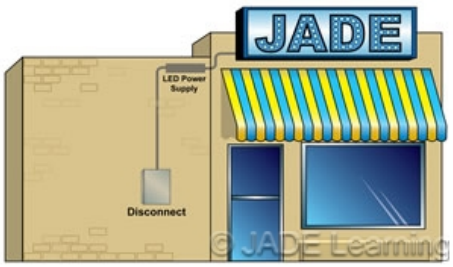
A new Informational Note gives examples of lighting technologies used in signs, including cold cathode neon tubing, high intensity discharge lamps (HID), fluorescent or incandescent lamps, and light-emitting diodes (LEDs).

Question 61: Which of the following installations is not covered by Article 600, Electric Signs and Outline Lighting?

A: Baseball park lighting for night games.
B: Baseball park scoreboard.
C: Baseball park concession stand neon lighting.
D: Baseball park scrolling advertising sign.

## Question 62: 600.2 Definitions. LED Sign Illumination System.

Question ID#: 187.0




***LED Sign Illumination Systems are now recognized by the NEC.***

An LED Sign Illumination System is, a ***complete lighting system for use in signs and outline lighting consisting of light-emitting diode (LED) light sources, power supplies, wire, and connectors to complete the installation.***

LEDs are becoming increasingly popular in many different applications, including in luminaires and electric signs, and were first introduced into the NEC in the 2008 NEC for use in clothes closets.

A light-emitting diode (LED) is a semiconductor light source that produces light as current flows through the device. LEDs consume up to 80% less energy than conventional incandescent bulbs. LEDs are an efficient lighting option that create light without releasing significant amounts of heat, last longer than compact fluorescent lights (CFLs), and don't contain mercury.

Question 62: Which of the following is a correct statement about LED sign illumination systems?

A: Heat generated by LEDs are a concern for luminaire manufacturers.
B: LEDs are more expensive to operate than compact fluorescent lamps.
C: LEDs consume less energy than incandescent lamps.
D: LEDs require a high voltage ballast.

## Question 63: 600.4(C)&(D) Visibility and Durability.

Question ID#: 188.0


***Electric sign markings are no longer required to be visible after installation.***

Electric signs and outline lighting systems must be marked with the manufacturer's name, trademark, input voltage and current rating.

The 2008 NEC required these markings to be visible after installation. The 2011 NEC no longer requires them to be visible after installation. Now they can be applied in a location visible during servicing. Not having the input voltage and current rating of a sign visible after the installation is complete will make it harder for inspectors to determine if the sign has been installed according to Code. It may make it easier for service personnel working on the sign.

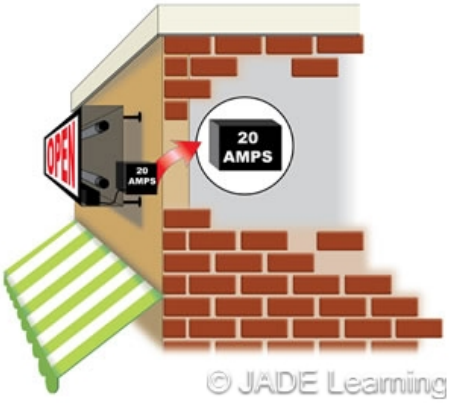
Marking labels for signs must be permanent, durable, and weatherproof when installed in a wet location. If the label is not readable because it has been exposed to the weather, the information on the label cannot be used to aid an inspector, installer or service personnel.

Question 63: Which one of the following electric signs is required to have a weatherproof marking label?

A: An outdoor drive-thru menu sign at a fast food restaurant.
B: A sign inside a barbershop window.
C: A menu sign inside a cafeteria.
D: A directory sign inside a shopping mall.

## Question 64: 600.5(B) Rating.

Question ID#: 189.0




***Except for neon signs, the minimum rating of branch circuits supplying signs is 20 amps.***

Branch circuits that supply signs are to be considered a continuous load. A continuous load is a load where the maximum current is expected to continue for 3 hours or more.

The rating limits for each sign type remains the same. Branch circuits that supply neon tubing installations shall not be rated in excess of 30 amps. Branch circuits that supply all other signs shall be rated not to exceed 20 amps. LEDs are considered as other signs.

Section 210.19(A)(1) states that branch circuit conductors shall have an allowable ampacity not less than 125% of the continuous load. The maximum permitted load on a branch circuit for a LED type sign is 16 amps.

To calculate the maximum continuous load that can be put on a circuit, divide the circuit rating by 125 %. As a decimal 125% = 1.25. ***For example:*** to find the maximum continuous load that can be carried on a 50 amp circuit: 50 A / 1.25 = 40 A

Question 64: What is the maximum load permitted on a 30 amp neon tubing branch circuit?

A: 16 amps.
B: 20 amps.
C: 24 amps.
D: 30 amps.

## Question 65: 600.6 Disconnects.

Question ID#: 190.0


***Circuits supplying signs are not permitted to supply other loads.***

The disconnecting means for a sign, outline lighting system, or skeleton tubing must open all ungrounded conductors of the feeder or branch circuit, must be externally operable and cannot control any other loads. Skeleton tubing is neon tubing that is itself the sign or outline lighting and is not attached to an enclosure or sign body.

The switch or circuit breaker that serves as the disconnect must open all ungrounded conductors of a multiwire branch circuit simultaneously. A 2-pole or 3-pole circuit breaker or single-pole circuit breakers with identified handle ties can serve as the simultaneous disconnecting means.
Multiwire branch circuits work well as the electrical supply for signs and outline lighting, just as they do for luminaires. The requirement to have a simultaneous disconnecting means for the ungrounded conductors in a multiwire branch circuit will protect personnel servicing the sign by guaranteeing all phases of the multiwire branch circuit are disconnected at the same time.

Question 65: If the disconnect is listed for the application, opens all ungrounded conductors simultaneously, is lockable, and is rated for the voltage and amperage of the circuit for the sign it supplies, which of the following disconnects does not comply with the NEC requirements for the installation?

A: A disconnect for a single-phase, 240-volt feeder if the disconnect is installed on the exterior of a sign adjacent to the point where conductors enter the sign.
B: A disconnect for a 120-volt branch circuit if the disconnect is installed on a building adjacent to the point where conductors enter the sign.
C: A disconnect for a 208-volt multiwire branch circuit if the disconnect is installed inside the sign it supplies behind a panel secured by hex-head screws.
D: A 3-pole disconnect for a 208-volt multiwire branch circuit that supplies the sign on which the disconnect is installed if the disconnect is installed on the exterior of a sign adjacent to the point where conductors enter the sign.

## Question 66: 600.7(B)(1) Exception. Grounding and Bonding. Bonding. Bonding of Metal Parts.

Question ID#: 191.0


***Metal LED and other lighting system components supplied by Class 2 power supplies are not required to be connected to an equipment grounding conductor.***

Previous codes required all metal parts of a sign or outline lighting system to be bonded to the equipment grounding conductor regardless of the voltage. The new exception waives that requirement when the equipment is supplied by Class 2 circuits. LED signs are usually wired with Class 2 circuits.

This new exception recognizes the limits of low voltage systems supplying signs and outline lighting. Low voltage circuits are not a shock hazard. The new exception applies to the remote metal parts of the sign that are connected only to the low-voltage circuit supplied by the Class 2 transformer or power supply. If higher voltages are present the sign must be bonded to the power supply.
The equipment grounding conductor of the supply circuit to the Class 2 transformer or power supply is required to be connected to the metal enclosure where the Class 2 transformer or power supply is installed. UL standard 48, Standard for Electric Signs, has similar requirements.

Question 66: A convenience store has four electric signs. Which sign is not required to be bonded to an equipment grounding conductor?

A: A 120 volt section sign displaying fuel prices.
B: An outline lighting entrance sign supplied by a 100 watt, Class 2 transformer.
C: A three section 120 volt sign mounted above a refrigeration case.
D: An exit sign.

## Question 67: 600.33 LED Sign Illumination Systems, Secondary Wiring.

Question ID#: 192.0


***Class 2 wiring methods for LED signs are now included in Article 600.***

LED sign illumination systems are supplied with Class 2 wiring from the secondary side of a Class 2 transformer or power supply. Before this section was added to Article 600, the rules for Class 2 Wiring were in Article 725. Since LED signs are very popular, the wiring method for LED signs, Class 2 type wiring, was added to Article 600, Electric Signs and Outline Lighting.

Wiring for LED sign illumination systems must be:

- Installed according to the manufacturer's instructions.
- Wired with listed Class 2 cable on the load side of the power source.
- Sized no smaller than No. 22 AWG.
- Identified for wet locations when used in wet locations.
- Supported in a neat and workmanlike manner without damaging the cable.
- Connected with listed insulating devices and accessible after installation.
- Protected from physical damage.
- Properly grounded and bonded.

Question 67: Which of the following installations of wiring for an LED sign is a Code violation?

A: Cable bundled and supported by cable ties.
B: Cable stapled to a wood framing member.
C: Cable installed in a raceway.
D: Cable supported by ceiling tiles in a suspended ceiling.

## Question 68: 604.6(A)(2) Exception No. 3.

Question ID#: 193.0


***Noncircular, unlisted flexible metal conduit is permitted in manufactured wiring systems if preassembled with fittings and conductors.***

A manufactured wiring system is defined as a system containing component parts that are assembled in the process of manufacture and cannot be inspected at the building site without damage or destruction to the assembly; the system is used for the connection of luminaires, utilization equipment, continuous plug-in type busways, and other devices.

This new exception would permit the use of unlisted flexible metal conduit of noncircular cross section or trade sizes smaller than permitted by 348.20(A), or both, provided the wiring systems are supplied with fittings and conductors at the time of manufacture.
The new exception will permit the unlisted flexible metal conduit, but only when it is evaluated as part of a listed assembly that is listed for compliance with the UL standard for manufactured wiring systems.

Question 68: Which one of the wiring methods listed below is not permitted for manufactured wiring systems?

A: Listed flexible metal conduit.
B: Listed liquidtight metallic conduit.
C: Intermediate metal conduit.
D: Unlisted flexible metal conduit with fittings installed by the manufacturer.

## Question 69: 620.53 Exception. Car Light, Receptacles(s) and Ventilation Disconnecting Means.

Question ID#: 194.0

The general rule in 620.53 requires a single disconnecting means for a branch circuit that supplies the elevator car light, receptacles and ventilation. Under the general rule, the disconnect must be a fused motor switch.


***There are three options for disconnecting power for elevator car lighting, receptacles, and ventilation motors.***

However, the new exception in section 620.53 permits the disconnecting means for individual branch circuits supplying elevator car lighting, receptacle(s), and a ventilation motor not exceeding 2 HP to be any of the disconnecting means listed in section 430.109(C) which permits the disconnecting means to be one of the following types:

- a general-use switch with a rating not less than twice the full-load current rating of the motor.
- a general-use snap switch suitable only for use on AC, where the motor full-load current rating is not more than 80% of the ampere rating of the switch.
- a listed manual motor controller having a horsepower rating not less than the rating of the motor.

When the branch circuit serves only elevator car lighting, receptacles or ventilation, which is commonly a 1/4 HP motor, requiring a fused motor circuit switch was too strict.

The disconnecting means still must be capable of being locked in the open position and the locking device must remain in place with or without the lock installed. Portable means of locking the disconnect in the open position are not permitted.. Disconnects permitted by 620.53 are required to comply with 430.109(C) and 430.104 which require the disconnect to be capable of being locked in the open (OFF) position and to indicate the ON and OFF position for the disconnect.

Regardless of which type of disconnect is used it is required to be installed in a machine or control room or space that is readily accessible to only qualified persons. The disconnects are not permitted to be installed within the hoistway.

Question 69: Which of the following disconnecting means can be used for disconnecting the car light and a ventilation motor with a full load current of 15-amps in an elevator supplied by a 125-volt AC branch circuit?

A: DC switch with a 125-V, 15-amp rating.
B: A general-use AC snap switch with a 125-V, 15-amp rating.
C: A listed manual motor controller marked "Suitable as Motor Disconnect" that is rated for not less than the rating of the motor.
D: A circuit breaker with a temporary locking device that can be removed when the lock is not attached.

## Question 70: 625.2 Definitions. Plug-in Hybrid Electric Vehicle (PHEV).

Question ID#: 195.0


***Plug-in Hybrid Electric Vehicles (PHEV) are intended for on-road use.***

According to the definition in 625.2, a ***Plug-in Hybrid Electric Vehicle (PHEV)*** is ***A type of electric vehicle intended for on-road use with the ability to store and use off-vehicle electrical energy in the rechargeable energy storage system, and having a second source of motive power.***

A hybrid electric vehicle has an onboard battery that can be recharged from an off-vehicle source like a charging station, and it has a second source of power. Even though PHEVs are not totally electric they are still classified as electric vehicles.

Unlike total electric vehicles, the plug-in hybrid electric vehicle combines a conventional internal combustion engine with a rechargeable battery to achieve better fuel economy than a conventional vehicle.
The new definition indicates that these vehicles are intended for on-road use such as in passenger automobiles, buses, trucks, vans, and neighborhood electric vehicles.

Question 70: Which of the vehicles listed below is a plug-in hybrid electric vehicle?

A: Electric fork-lift.
B: Automobile for off-road use with a battery that is a source of motive power and an onboard internal combustion engine that recharges the battery.
C: Golf cart.
D: An automobile for on-road use with a battery that is a source of motive power which can be recharged from an off-vehicle source and an internal combustion engine which is a second source of motive power.

## Question 71: 625.2 & 625.21 Electrical Vehicle Charging System. Definitions. Rechargeable Energy Storage System.

Question ID#: 196.0


***A readily accessible disconnect is required for electric vehicle charging equipment rated more than 60 amperes.***

A rechargeable energy storage system is ***any power source that has the capability to be charged and discharged.*** Informational Note: ***Batteries, capacitors, and electromechanical flywheels are examples of rechargeable energy storage systems.***

Rechargeable plug-in electric vehicles for on-road use are here now. Charging stations are being installed across the country to provide a way to extend the driving range of these vehicles. Charging stations for electric vehicles provide the biggest opportunity for the electrical industry since air conditioning.

Most charging stations for plug-in hybrid electric vehicles will operate at 240 volts, single phase. A standardized connector from the charging station plugs into the vehicle and can recharge the battery in a matter of hours. The electric vehicle connector on the charging station transfers power to the battery and sets up an information link between the charger and vehicle battery. Section 625.21 requires overcurrent protection for the feeder or branch circuit supplying the charging station to be sized at 125% of the maximum load of the electric vehicle supply equipment. A disconnecting means for vehicle supply equipment rated more than 60 amperes or more than 150 volts to ground is required in a readily accessible location.

Question 71: An electric vehicle charging station is rated for 30 amps. What is the maximum rating of the overcurrent device for the branch circuit supplying the charging station?

A: 40 amps.
B: 50 amps.
C: 60 amps.
D: 100 amps.

## Question 72: 626.24(B)(1) Electrified Truck Parking Spaces. Receptacle.

Question ID#: 197.0

***A minimum of two circuits are required to supply the 125 volt GFCI receptacles for electrified truck parking space equipment.***

Electrified truck parking spaces allow the truck driver to heat and cool the truck cab and keep a refrigerated trailer energized without running the truck engine.

The electrified truck parking supply equipment that provides power and other services like TV and Internet to the cab of the truck can have a maximum of three GFCI protected duplex receptacles. The 2008 NEC required single receptacles. Single receptacle GFCI protected receptacles did not exist in 2008, so the GFCI protection was in a remote panelboard. If the GFCI circuit breaker tripped, the truck driver may not have ready access to reset it.

The 2011 NEC permits either single or duplex GFCI receptacles for Electrified Truck Parking Spaces. This change allows the receptacles to be supplied by non-GFCI protected circuits; if a ground fault causes the GFCI receptacle to trip, it can be reset locally by the trucker.

The GFCI receptacles must be the grounding type and rated 20 amperes, 125 volts, and two of the three receptacles must be on separate circuits which means that two of the three duplex receptacles are permitted to be on the same circuit.
Twist-lock receptacles are not used because of the danger of damaging the receptacle if the driver pulled away from the parking space with cords plugged into the electrical equipment.

Question 72: A maximum of 3 receptacles, each 2-pole, 3-wire grounding type, rated 20 amperes, 125 volts, and GFCI-protected are permitted at an electrified truck parking space. How many of those receptacles can be connected to the same circuit?

A: 6
B: 3
C: 2
D: 1

## Question 73: 645.1 Scope.

Question ID#: 198.0


***Wiring for information technology equipment is normally done under raised floors using wiring methods permitted in Article 645.***

The Informational Note in the scope of this section refers to NFPA 75-2009, Standard for the Protection of Information Technology Equipment. This standard covers requirements for protecting both information technology equipment and information technology equipment areas. An information technology area could be a large data center or a single room that contains computer equipment along with the interconnecting wiring.

All the requirements of Chapters 1-4 do not apply to Article 645, Information Technology Equipment. Section 90.3, Code Arrangement, says that Chapters 1-4 apply generally to all electrical installations, but that Chapters 5-7 can modify the requirements in Chapters 1-4. For example, only the wiring methods in Chapter 3 that are specifically cited in Article 645 apply to information technology equipment and information technology areas. Much of the wiring for information technology equipment is done under raised floors and wiring is required to be in a raceway or in Type MI, MC or AC cable.

Question 73: What wiring method listed below is not permitted to supply branch circuits for field-wired equipment under a raised floor in an information technology room?

A: Flexible metal conduit.
B: Liquidtight flexible metal conduit.
C: Liquidtight flexible non-metallic conduit.
D: Non-metallic sheathed cable.

## Question 74: 645.2 Definitions: Information Technology Equipment (ITE).

Question ID#: 199.0


***Information Technology Equipment is different than communications equipment.***

Information Technology (IT) Equipment is defined as "***equipment and systems rated 600 volts or less, normally found in offices or other business establishments and similar environments classified as ordinary locations, that are used for creation and manipulation of data, voice, video, and similar signals that are not communications equipment as defined in Part 1 of Article 100 and do not process communications circuits as defined in 800.2".***

It is important to distinguish between IT equipment and communications equipment in order to know which Article applies. Communications equipment is telephone equipment, and although telephone wiring is getting very similar to computer wiring, Article 800 governs telephone wiring and Article 645 governs information technology wiring. When telephone and information technology equipment are installed in the same building, Article 645 applies to the information technology equipment and Article 800 applies to the equipment that processes communications circuits.

Question 74: Which types of equipment are classified as information technology equipment and would be required to be installed according to Article 645?

A: A cell tower.
B: A telephone exchange.
C: A permanently installed hard wired data storage device.
D: A controller for a building automation system.

## Question 75: 645.4 Special Requirements for Information Technology Equipment Room.

Question ID#: 200.0

Wiring in Information Technology (IT) equipment rooms can be done according to Article 645 if the room meets all the requirements of 645.4. Some of the wiring practices in Article 645 are not as strict as in Chapters 1-4. For example, liquidtight flexible non-metallic conduit is permitted under raised floors in an IT equipment room, but it is not permitted as plenum wiring in 300.22. Because of the less strict requirements in Article 645 for IT equipment rooms, all the requirements of 645.4 must be met for the room to be classified as an IT equipment room.


***To be classified as an information technology room specific criteria must be met.***

Except where supplied by an Integrated Electrical System covered by Article 685, an IT equipment room must have all of the following:

- A remote disconnect to remove power from all electronic equipment in the room or in zones in the room and a separate disconnecting means to disconnect dedicated HVAC equipment serving the IT areas. The two disconnecting means are permitted to be controlled by one device like a switch or pushbutton.
- A separate heating/ventilating system dedicated to the IT equipment room or zones.
- An access control system limits entry to the room to only authorized persons.
- Fire-resistant-rated walls, floors , and ceilings that separate the IT equipment room from other rooms.
- Only electrical equipment associated with the operation of IT equipment is permitted in IT rooms or zones.

Question 75: Which of the following is not a requirement for an information technology room?

A: A room with IT equipment and HVAC equipment that serves only the IT equipment room.
B: A room with IT equipment and two exits.
C: A room with IT equipment and fire resistant walls, floors and ceilings.
D: A room with IT equipment and locked doors that limit who can enter the IT room.

## Question 76: 645.5 Supply Circuits and Interconnecting Cables.

Question ID#: 201.0

Information technology equipment is permitted to be connected to a branch circuit by a power-supply cord. The power-supply cord cannot be longer than 15 ft. and it must be listed and of a type permitted to be used on information technology equipment. A power-supply cord can be fabricated in the field if listed flexible cord, listed attachments plugs, and listed cord connectors permitted for informational technology equipment are used.


***Metallic and non-metallic boxes and some types of non-metallic raceways are permitted under the raised floor of an IT Equipment room.***

Interconnecting cables and cable assemblies between separate units of information technology equipment must be listed. The 15 ft. limitation that applies to power-supply cords does not apply to interconnecting cables.

Where exposed to physical damage, power-supply cords and interconnecting cables must be protected.
Under raised floors, metallic and non-metallic boxes and enclosures are permitted. Selected types of non-metallic raceways, such as electrical nonmetallic tubing, non-metallic surface raceways and liquidtight flexible non-metallic conduit are also allowed.

Question 76: Which of the following installations of IT equipment supply circuits and interconnecting cables is a Code violation?

A: A 10 ft. listed power-supply cord.
B: A 25 ft. listed interconnecting cable.
C: A non-metallic enclosure installed under a raised floor.
D: A 20 ft. power-supply cord made up of a listed cord and listed cord connectors.

## Question 77: 645.10 Disconnecting Means.

Question ID#: 202.0

An approved means to disconnect power to all electronic equipment and the HVAC system in the IT equipment room must be provided. The 2008 NEC required the controls for the disconnects to be located at a readily accessible location at the principal exit doors. The disconnect control could be a pushbutton or selector switch. Being located at the exit doors meant it could be easily operated by accident or by sabotage.


***The disconnect for IT equipment power is no longer required to be located beside an exit door.***

To solve this problem, the 2011 NEC permits the disconnect control to be mounted remotely in a manager's office or a similar location. The remote disconnect control must be in a location that is readily accessible to authorized persons and emergency responders. It must be identified as a disconnect, and it can be guarded with a cover or other means. Remote disconnect controls for the electronic equipment power and the HVAC systems shall be grouped and identified. A single control such as a pushbutton can operate the disconnecting means for both the IT equipment and HVAC system.

Critical Operations Data Systems are information technology systems that support public safety, emergency management, national security, or business continuity. A remotely controlled disconnecting means for the IT equipment for Critical Operations Data Systems is not required, provided the IT room or zone has smoke detectors, fire suppression systems, qualified people available to meet emergency personnel, an established procedure to remove power and air movement from the IT area, and approved cable and raceways installed under raised flooring.

Question 77: Which of the following is a true statement about disconnecting means for information technology equipment?

A: The controls for disconnecting power to IT equipment must be located at the exits of the information technology room.
B: Remote disconnects for IT room equipment and the IT room HVAC system shall be grouped and identified.
C: Disconnects for IT equipment must be located inside the information technology room.
D: Separate controls to operate disconnects for the information technology equipment and HVAC systems are required.

## Question 78: 645.25 Engineering Supervision.

Question ID#: 203.0

Information technology rooms have special needs. Data centers consume huge amounts of power in equipment and cooling load. Densely packed computer equipment creates a high ratio of kW per square ft. and a great deal of heat. Most data centers have a load density of between 30 and 70 watts per sq. ft.

The standard load calculations in Article 220 for feeders and services may not yield a total load that is large enough for the actual connected load. The demand factors in Article 220 that assume a diversity of load may not be accurate for information technology equipment that runs simultaneously and continuously.
The load calculations for services and feeders in a data center can be done by qualified persons under engineering supervision, without having to follow each requirement in Article 220. This will give the designer of data centers and information technology rooms more flexibility in calculating and selecting service and feeder conductors and equipment.


***Calculations for Information Technology facilities done according to Article 220 may not be adequate to determine the system requirements.***

Question 78: Which of the following is permitted to supervise a qualified person who is performing load calculations for a data center?

A: A licensed master electrician.
B: A licensed architect.
C: A licensed professional electrical engineer.
D: A licensed journeyman electrician.

## Question 79: 670.5 Industrial Machinery. Short-Circuit Current Rating.

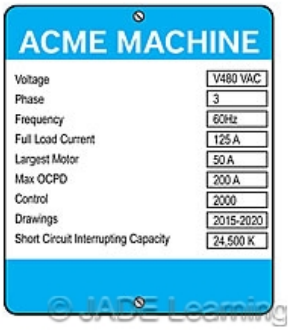
Question ID#: 204.0

***Industrial machinery shall not be installed where the available fault current exceeds its short-circuit current rating as marked in accordance with 670.3(A)(4).***

If the available fault current is greater than the short-circuit rating of electrical equipment, a fault on the system can cause the electrical components to explode, creating a hazard to anyone in the area.

This new section in Article 670, Industrial Machinery, makes it clear that the short-circuit current rating marked on the machine or control panel nameplate is the value which is to be used to determine if the short-circuit current rating is large enough for the available fault current.

Components inside the control panel have short-circuit current ratings which may be different than the short-circuit current ratings on the machine nameplate itself. This caused confusion about which short-circuit current rating should be used to determine if the available fault current exceeded the machine's maximum short-circuit current rating.
The marked short-circuit current rating on the nameplate of the control panel or machine must not be less than the available fault current.




***The marked short-circuit current rating on the nameplate of an industrial control panel must not be less than the available fault current.***

Question 79: If the available fault current at an industrial machine is 48,000 amps, which of the following statements is true?

A: The short-circuit current rating on the overcurrent device for the largest motor is used to determine if the industrial machine can be installed.
B: The short-circuit current rating of the service equipment is used to determine if the industrial machine can be installed.
C: The short-circuit current rating of the industrial machine feeder disconnect is used to determine if the industrial machine can be installed.
D: The short-circuit current rating on the industrial machine nameplate must be equal to or greater than 48,000 amps.

## Question 80: Table 680.10 Swimming Pools, Fountains, and Similar Installations. Minimum Cover Depths.

Question ID#: 205.0


***Use Table 680.10 for the minimum cover depths of underground raceways for pools and hot tubs.***

Wiring can never be installed underneath a swimming pool or within 5 ft. horizontally from the inside wall of a pool, spa or hot tub unless it is required to supply pool equipment permitted in Article 680. However, where required by space limitations, underground wiring not associated with a pool is permitted within 5 ft. of the pool wall when installed as a complete raceway system using RMC, IMC, or a non-metallic raceway. The burial depth of conduit within 5 ft. of the pool is shown in Table 680.10. A revision to the Table permits a reduction of the burial depth to 6 inches for non-metallic raceways listed for direct burial under a minimum of 4 inches of concrete which extends not less than 6 inches beyond the underground installation.

The 2008 NEC required non-metallic conduit to be buried 18 inches; the burial depth was the same whether it was buried below concrete or not.
Table 300.5 permits a reduced burial depth of 4 inches whenever a non-metallic raceway is installed under a minimum of 4 inches of concrete. However, in the 2011 NEC, if the non-metallic conduit is installed within 5 ft. of a swimming pool, spa or hot tub, Table 680.10 requires the non-metallic conduit to be installed a minimum of 6 inches deep if covered by at least 4 inches of concrete.

Question 80: What is the minimum burial depth for a run of Rigid PVC conduit installed within 2 feet of the edge of a swimming pool under a 4 inch concrete slab?

A: 4 inches.
B: 5 inches.
C: 6 inches.
D: 18 inches.

## Question 81: 680.21(A)(5) Motors - Cord-and-Plug Connection.

Question ID#: 206.0


***Swimming pool pump motors are permitted to be hard-wired or cord-and-plug connected.***

Swimming pool pump motors are permitted to be cord-and-plug connected. The flexible cord cannot be longer than 3 ft. and it must include a copper equipment grounding conductor selected from Table 250.122 that is not smaller than No. 12 AWG. The cord must terminate in a grounding-type attachment plug.

The changes in this section require that the equipment grounding conductor be copper No. 12 AWG or larger in size. These requirements were added because Part I, General, section 680.7(B) requires cord-and-plug-connected equipment cords to have a copper equipment grounding conductor not smaller than No. 12 AWG. Now both sections say the same thing, and there is no conflict between the general requirement for cord-and-plug-connected equipment and the requirement for cord-and-plug connections to a pool pump motor in a permanently installed pool.

Question 81: A swimming pool pump motor is cord-and-plug-connected. The branch circuit overcurrent device is a 15 ampere, 2-pole GFCI circuit breaker. The pump motor overload protection is set at 6 amperes. What is the required minimum size copper equipment grounding conductor in the cord?

A: No. 12 AWG.
B: No. 14 AWG.
C: No. 16 AWG.
D: No. 18 AWG.

## Question 82: 680.21(C) GFCI Protection.

Question ID#: 207.0


***A single-phase, 120 volt - 240 volt, 15 or 20 amp pool pump motor is required to be GFCI protected whether it is hard-wired or cord-and-plug connected.***

Pool pump motors are required to be GFCI protected if the pump is connected to a single-phase, 120 volt through 240 volt branch circuit rated 15 or 20 amps. GFCI protection is required whether the pool pump motor is hard-wired or cord-and-plug connected to a receptacle.

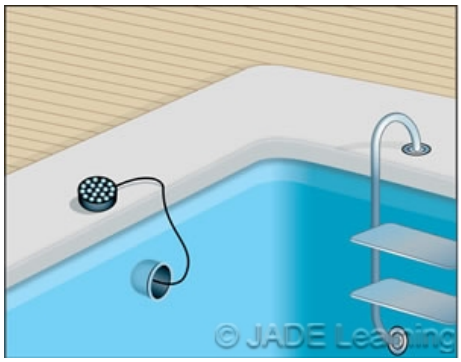
The requirement for GFCI protection for pool pump motors was moved from a section on area lighting, receptacles and equipment in the 2008 NEC to the section on motors in the 2011 NEC. In addition to relocating the requirement, the voltage range was changed from ***125 volts or 240 volts*** in the 2008 Code to ***120 volts through 240 volts*** in the 2011 NEC. With the change, 208 volt and 230 volt rated motors are covered.

Question 82: Which hotel swimming pool pump motor listed below requires GFCI protection?

A: Single-phase, 120 volt, 20 amp rated.
B: Three-phase, 208 volt, 20 amp rated.
C: Single-phase, 240 volt, 30 amp rated.
D: Single-phase, 277 volt, 15 amp rated.

## Question 83: 680.23(A)(3) Underwater Luminaires. GFCI Protection. Relamping.

Question ID#: 208.0




***GFCI protection is not required for underwater luminaires that operate at or below the low voltage contact limit.***

GFCI protection of underwater luminaires that operate at or below ***the low voltage contact limit*** no longer require GFCI protection. The change was made because LED lighting for underwater luminaires is very popular and is connected to power supplies that operate below the low voltage contact limit.

The low voltage contact limit is defined in 680.2 as:

- 15 volts (RMS) sinusoidal AC
- 21.2 volts peak nonsinusoidal AC
- 30 volts continuous DC
- 12.4 volts peak DC that is interrupted at a rate of 10 to 200Hz

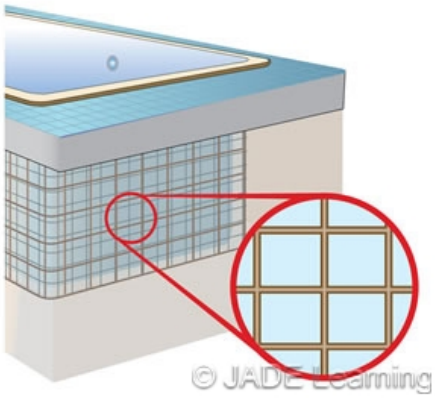
Underwater LED luminaires that operate below these voltage thresholds do not pose a shock hazard during relamping or at other times and do not require GFCI protection.

Question 83: Luminaires listed for which of the following voltages are required to be installed on GFCI protected branch circuits?

A: 15 volt RMS sinusoidal AC.
B: 21.2 volt peak nonsinusoidal AC.
C: 30 volt continuous DC.
D: 120 volt RMS sinusoidal rated AC.

## Question 84: 680.26(B)(1)(b) Equipotential Bonding. Bonded Parts. Conductive Pool Shells.

Question ID#: 209.0




***Concrete swimming pool shells are considered to be conductive and required to be bonded to the equipotential grid.***

Concrete pools are considered to be electrically conductive shells regardless of their construction. Section 680.26(B)(1) requires conductive shells to be bonded to the equipotential grid to reduce voltage gradients in the pool area by one of two methods:

- Bonding uncoated structural rebar in the concrete together with steel tie wires.
- If the rebar is coated with a nonconductive covering, a grid of copper conductors is required to be installed within 6 inches of the pool shell.

Regardless of which method is used, the copper grid or rebar is connected by a No. 8 AWG, or larger, solid copper conductor to the equipotential bonding grid.

When a copper conductor grid is used to create an equipotential bonding grid for an in-ground pool, the No. 8 AWG bare solid copper conductors that make up the grid must be bonded at all points of crossing. The 2008 NEC did not specify how to make the connections at the crossing points. The 2011 NEC requires the connections to be made according to 250.8 or by other approved means.

Section 250.8 includes the following devices or methods as a way to make the connection: Listed pressure connectors, terminal bars, other connectors listed for grounding and bonding equipment, or by exothermic welding processes or other means listed for grounding and bonding equipment.

The copper conductor grid is only required to conform to the contour of the pool. The 2008 NEC required the copper conductor grid to conform to the contour of the pool and the pool deck. Equipotential bonding for the deck is different than for the pool shell. The NEC calls the pool deck a perimeter surface. Its bonding requirements are covered in 680.26(B)(2)(b). Bonding is done by one of two methods:

- Bonding uncoated structural rebar in the concrete together with steel tie wires.
- Bonding rebar with a single solid bare copper No. 8 AWG conductor connected to the reinforcing steel or copper conductor grid at four points.

Question 84: Which of the following statements about the copper conductor grid for a swimming pool shell is true?

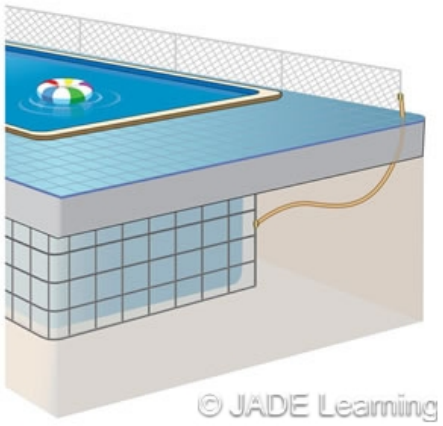
A: Steel tie wires are permitted to connect the copper conductor grid together.
B: The copper conductor grid is required for both the pool shell and the perimeter surface.
C: The copper conductor grid is permitted to be connected together with listed pressure connectors.
D: The copper conductor grid is constructed using a minimum No. 10 AWG bare copper conductor.

## Question 85: 680.26(B)(7) Equipotential Bonding. Bonded Parts. Fixed Metal Parts.

Question ID#: 210.0

All metal parts that are part of the pool or located within 5 ft. horizontally ***and*** 12 ft. vertically from the pool must be bonded together and connected to the equipotential bonding grid. This includes, but is not limited to, metal-sheathed cables and raceways, metal piping, metal awnings, metal fences, metal ladders, and metal door and window frames.

It does not seem likely that metal door and window frames will become energized. However, the purpose of the equipotential bonding grid is not to provide a path for fault current if a metal object becomes energized. The purpose of the bonding grid is to reduce voltage differences in the pool area. If there is no difference in voltage potential between any two objects in the pool area, then the risk of electric shock is reduced.
Exception No. 1 was revised to make it clear that only those metal parts that were separated from the pool by a permanent barrier that prevents contact by a person with any metal part are not required to be bonded.




***All metal parts that are part of the pool or located close to the pool are required to be bonded to the equipotential bonding grid.***

Question 85: Which of the following items listed below would not be required to be bonded to the equipotential bonding grid?

A: A metal fence located within 4.5 feet from the edge of the pool.
B: A metal pool house door located within 5 feet from the edge of the pool.
C: A metal awning located 15-feet high covers a pool. No part of the awning or its supports is within 5 feet from the edge of the pool.
D: A metal luminaire pole located within 4 feet from the edge of the pool.

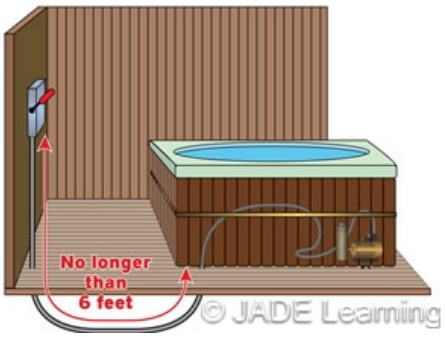
## Question 86: 680.42(A)(1) Outdoor Installations. Flexible Conduit.

Question ID#: 211.0

An outdoor spa or hot tub with a factory-installed control panel or panelboard can use flexible wiring methods to connect the spa equipment to the control panel or panelboard. In the 2008 NEC, liquidtight flexible metal conduit or liquidtight flexible non-metallic conduit was permitted in lengths of not more than 6 ft.

The 2011 NEC permits 6 ft. of liquidtight flexible metal conduit or liquidtight flexible non-metallic conduit ***external to the spa or hot tub enclosure in addition to the length needed within the enclosure to make the electrical connection.***

The flexible conduit inside the hot tub or spa enclosure is protected from physical damage and is not counted in the total run of flexible conduit. Outside the hot tub or spa enclosure, the length of the flexible conduit is still limited to 6 ft.
Under the 2008 NEC with only a total of 6 ft. of liquidtight flexible metal conduit or liquidtight flexible non-metallic conduit allowed, it was necessary to install a fitting on the flexible conduit to make the transition to a different wiring method. The fitting was a weak point in the installation and if it pulled apart it would create a hazard. A single run of liquidtight flexible metal conduit or liquidtight flexible non-metallic conduit, without a fitting to change wiring methods, is a safer installation.




***LFMC and FMC is limited to 6 ft. outside the hot tub enclosure, but any length is permitted inside the enclosure.***

Question 86: Which of the following installations for outdoor spas or hot tubs is permitted by the 2011 NEC?

A: A 16 ft. run of flexible non-metallic conduit with 10 ft. of the flexible conduit outside of the hot tub or spa enclosure.
B: A 12 ft. run of flexible non-metallic conduit with 6 ft. of the flexible non-metallic conduit inside the hot tub or spa enclosure.
C: A 10 ft. run of flexible non-metallic conduit with 3 ft. of flexible conduit inside the hot tub or spa enclosure.
D: A 14 ft. run of flexible non-metallic conduit with 8 ft. of flexible conduit outside of the hot tub or spa enclosure.

## Question 87: 680.43 Exception No.2 Spas and Hot Tubs. Indoor Installations.

Question ID#: 212.0

An indoor listed self-contained spa or hot tub that is installed above a finished floor is no longer required to have an equipotential bonding plane around the perimeter surface of the spa or hot tub. If the spa or hot tub is sitting on the floor, but not installed in the floor, it is considered above the floor.

Some jurisdictions were requiring the floor around a new hot tub to be cut out to allow for the installation of an equipotential bonding conductor to be installed around the perimeter of the hot tub. This added considerable expense to the installation and caused problems between inspectors, installers and homeowners, without making the installation safer.
The exception was added because there were no known reported shock or electrocution incidents where people making contact with the spa or hot tub and the surrounding perimeter surface were injured by a failure to bond the perimeter surface around an indoor spa or hot tub. However, spas and hot tubs installed outdoors still require equipotential bonding around the perimeter of the spa or hot tub.


***An equipotential bonding plane is not required around an indoor listed self-contained spa or hot tub that is installed above a finished floor.***

Question 87: Which of the following installations would not require an equipotential bonding grid?

A: A hot tub located on an existing concrete patio in the backyard.
B: A spa located in a bonus room on a ceramic tile floor.
C: A spa located outside on a new concrete patio.
D: A hot tub located on the back porch on new brick pavers.

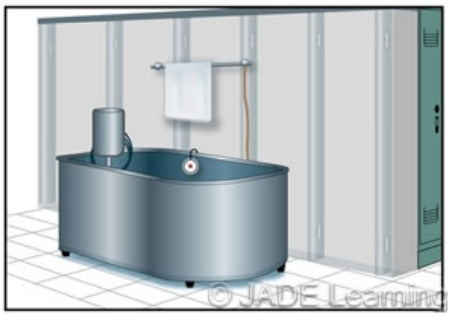
## Question 88: 680.62(B) Exception. Therapeutic Tubs (Hydrotherapeutic Tanks). Bonding.

Question ID#: 213.0

A therapeutic tub is a factory-fabricated, listed unit that is fastened in place with permanent piping or is not easily moved from one place to another. It is used for the submersion and treatment of patients.

In general, just like a spa or hot tub, the metal fittings, raceways and electrical equipment in a therapeutic tub must be bonded. A new exception has been added that exempts bonding requirements for small metal parts that are not likely to become energized. Air and water jets and drain fittings not connected to metallic piping, and towel bars, mirror frames, and similar non-electrical equipment not connected to metal framing, shall not be required to be bonded. Whether or not all small metal parts are considered likely to become energized will be decided by the enforcing authority.

The new exception is similar to an existing exception for small metal parts in and around spas and hot tubs.
If a metal part, such as a towel bar, is fastened to metal framing behind a wall covering, then the towel bar provides a path to ground; if it is within 5 ft. of the outside walls of the therapeutic tub, it must be bonded.




***Small metal parts of therapeutic tubs that are not likely to become energized are not required to be bonded. Other metal parts within 5 ft. of the tub must be bonded.***

Question 88: Which item listed below would not be required to be bonded?

A: A drain fitting connected to non-metallic piping in the bottom of a therapeutic tub.
B: A metallic pump motor located underneath a therapeutic tub.
C: A stainless steel grab bar attached to a therapeutic tub.
D: A stainless steel handrail fastened to metal framing behind a sheet rock wall located 4 ft. from a therapeutic tub.

## Question 89: 680.73 Hydromassage Bathtub - Accessibility.

Question ID#: 214.0

A hydromassage bathtub is a permanently installed bathtub with a recirculating piping system that is designed to accept, circulate, and discharge water with each use.

Hydromassage bathtubs are required to be supplied by an individual branch circuit and be protected by a readily accessible ground-fault circuit-interrupter. If it is considered as not being readily accessible, a GFCI receptacle mounted behind service access doors underneath the tub cannot provide the GFCI protection required by 680.71. Whether a GFCI receptacle behind an access door is considered readily accessible will be an AHJ call; it may depend on how the door is secured to the tub enclosure. However, in all cases, the GFCI protection is required to be provided by a readily accessible GFCI circuit breaker, GFCI receptacle, or a blank GFCI device installed in a readily accessible location.

When the supply receptacle for a cord-and-plug connected hydromassage tub is mounted behind a service access door, the receptacle must be installed so that its face is within direct view and not more than 1 ft. from the opening. This will permit easier access to the receptacle under the tub whenever the access door is open and will mean the hydromassage tub motor can be easily observed and disconnected for servicing.

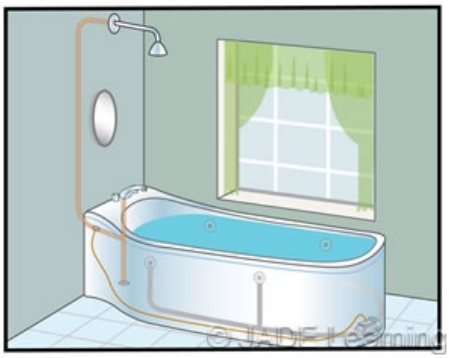
***A GFCI protected receptacle for a cord and plug connected hydromassage tub must be accessible.***

Question 89: If the receptacle provides the GFCI protection required by 680.71, which of the installations below is in compliance with the 2011 NEC?

A: A GFCI type receptacle located 12 inches behind a hydromassage bathtub access cover which is held in place by screws.
B: A GFCI protected receptacle located 10 inches behind a hydromassage bathtub access cover with the receptacle face positioned away from the access door.
C: A GFCI protected receptacle located 24 inches behind a hydromassage bathtub access cover with the face of the receptacle in direct view.
D: A GFCI protected receptacle for a hydromassage bathtub is located 8 inches behind a hinged access cover beside the tub. No tools are needed to open the cover and the face of the receptacle is in direct view when the cover is opened.

## Question 90: 680.74 Hydromassage Bathtubs - Bonding.

Question ID#: 215.0



***Hydromassage bathtub metal piping and all grounded metal parts in contact with the circulating water are required to be bonded together.***

All the metal piping associated with a hydromassage bathtub and all grounded metal parts in contact with the circulating water are required to be bonded together using a No. 8 AWG solid copper bonding jumper. The 2011 NEC requires the No. 8 AWG copper bonding conductor to be long enough to be connected to a replacement non-double-insulated pump motor at the hydromassage bathtub.

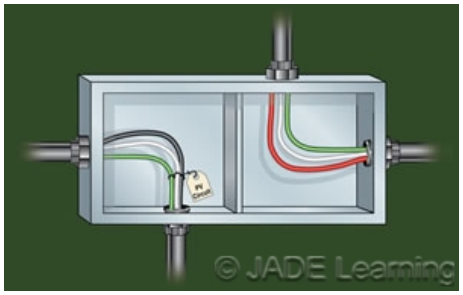
This bonding jumper is required to be connected to the branch circuit equipment grounding conductor when a double-insulated circulating pump motor is used. If a non-double-insulated circulating pump motor is used, the bonding jumper is terminated to the pump motor. The No. 8 AWG solid copper bonding conductor is never required to be run to the supplying panelboard. The No. 8 AWG solid copper bonding conductor is not required to be insulated.
The NEC does not indicate what to do with the bonding conductor in an initial installation of a double-insulated circulating pump where no metal piping and no grounded metal parts are used.

Question 90: Which bonding jumper listed below is permitted for bonding metal piping systems in contact with the hydromassage bathtub circulating water?

A: No. 12 AWG bare copper terminated to a non-double-insulated motor.
B: No. 10 AWG insulated copper terminated to a double-insulated motor.
C: No. 8 AWG stranded bare copper terminated to a non-double insulated motor.
D: No. 8 AWG solid copper terminated to a non-double-insulated motor.

## Question 91: 690.4(B) Installation. Identification and Grouping.

Question ID#: 216.0




***A partition is required to separate PV source and output circuits installed in a junction box from conductors of other systems.***

PV source and output circuits cannot be installed in the same raceway, cable tray, cable, outlet box, or junction box with conductors from other systems, unless there is a partition between the PV conductors and the conductors of the different systems. The wiring between the common connection point of a DC power system and PV modules and the wiring between PV modules themselves is a PV ***source*** circuit. The wiring between an inverter, or DC utilization equipment, and a PV source circuit is a PV ***output*** circuit.

The following PV system conductors must be identified and grouped as indicated. The means of identification shall be by separate color coding, marking tape, tagging, or other approved means.

- PV Source Circuits at all terminations, connections, and splices.
- PV Output and Inverter Circuits at all terminations, connections, and splices.
- Multiple Systems -Where conductors of more than one system are involved, identify the system at all terminations, connections, and splices. If the identification of the conductors is obvious by spacing or arrangement, identification of each system is not required.
- Grouping - If more than one system is installed in the same junction box or raceway that has removable covers, group AC conductors and DC conductors of each system separately with wire ties, spaced not more than 6 ft. apart. Grouping is not required if the circuit enters from a cable or raceway that makes the grouping obvious.

Question 91: Where conductor identification and grouping is not made obvious by termination and wiring methods, if PV-source circuits and output circuits are terminated in a combiner or junction box that also contains non-PV system circuit conductors, which of the following statements is true?

A: The PV source and output circuits should be grouped together as one bundle with tie wraps.
B: PV source and output circuits can never be installed in the same junction box.
C: The PV source and output circuits are not required to be identified at terminations or splices.
D: The PV source and inverter output circuits must each be identified differently and separated from non-PV system conductors by a partition.

## Question 92: 690.4(E) Installation. Wiring and Connections.

Question ID#: 217.0

***Only qualified persons should install photovoltaic circuits and systems.***

PV circuits, wiring and equipment shall be installed only by qualified persons. Article 100 defines a qualified person as ***"one who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved."***

Installing photovoltaic circuits and systems is a job that should only be performed by qualified electricians. Some energized PV circuits are no less hazardous than circuits supplied by a service or generator. There is a potential for danger from shock and arc flash in a PV system, just like in normal wiring.

PV wiring has much in common with residential and commercial wiring, but there are some unique differences. DC wiring, batteries, inverters and working with interconnected grid electric power sources may be new to many installers. There clearly is a demand for qualified PV technicians. Upgrading skills to include PV installations can be an exciting and rewarding opportunity.

Question 92: Which of the following individuals would be considered qualified to install solar photovoltaic systems?

A: An apprentice electrician.
B: A roofer/handyman.
C: A qualified electrician experienced with PV installations.
D: A general contractor.

## Question 93: 690.4(F) Installation. Circuit Routing.

Question ID#: 218.0

***PV conductors should be installed next to structural members to reduce the possibility of physical damage.***

PV wiring inside of a building must be routed along structural members such as beams, rafters, columns, and trusses. This is required even if the wiring is installed in conduit.

If there is a fire in the building, firefighters often break through the roof to allow for controlled air flow. If PV wiring is installed between the rafters or beams, it is likely a firefighter could cut into a live circuit and receive a shock. Since the PV disconnecting means is permitted inside the building, cuts in a circuit made by a fireman could be ahead of the disconnect or overcurrent protection. Installing PV conductors along structural members reduces the possibility of injury to firefighters. PV systems may be integrated into the roof of the structure. In those parts of the roof that are not covered by the PV modules themselves, or other PV equipment, the location of PV circuit wiring within a structural member must be clearly marked. The method of marking is not described. The reason for the marking is to prevent firefighters from cutting into energized PV wiring.

Question 93: Which of the following violates requirements for routing and installing PV circuit conductors that are not protected by being installed directly under a PV module?

A: PV source circuit conductors installed in EMT secured to a rafter 12-inches below the roof decking of a dwelling.
B: PV output circuit conductors installed in IMC under a truss in a commercial building.
C: PV source circuit conductors installed in MC-Cable that is run perpendicularly to rafters and is secured directly to the underside of 5/8 inch roof sheeting of a single family dwelling.
D: PV output circuit conductors in IMC that is imbedded within a built up roofing panel that is clearly and permanently marked to indicate the location of the conductors.

## Question 94: 690.10(E) Stand-Alone Systems. Back-fed Circuit Breakers.

Question ID#: 219.0


***Plug-in type, back-fed circuit breakers are required to be secured to panelboards by an additional fastener.***

Inverters in a PV system take the DC current from the PV modules or battery banks and convert it to AC current, usually at 240 volts, 60 HZ. These inverter output circuits are used to supply stand-alone loads in the facility and/or are connected to the utility grid through a backfed circuit breaker. A stand-alone load is supplied directly from the inverter without a connection to the utility. However, some PV systems have stand-alone loads and also a connection to the utility.

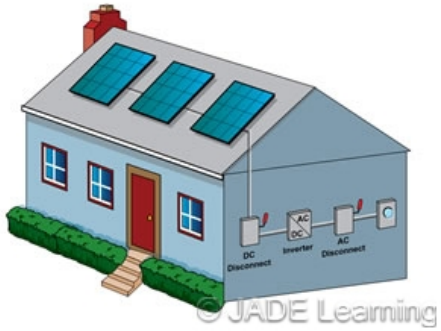
In the 2008 Code, a plug-in backfed circuit breaker from an inverter that supplied stand-alone loads and was tied to the utility gird was not required to be secured by an additional fastener. This has changed in the 2011 NEC. Now, plug-in type back-fed circuit breakers for stand-alone systems or utility-interactive systems are required to have an additional fastener ***that requires other than a pull to release the device from the mounting means on the panel 408.36(D).*** This requirement applies only to plug-in type circuit breakers, not the bolt-in type. If the circuit breaker is marked, "line" and "load" it cannot be backfed.
If an inverter that is connected to the utility grid senses a loss of power from the utility, it will instantly shut down. If a backfed circuit breaker supplied by the inverter output came loose from the panel, the inverter would shut down immediately. The real danger comes from a stand-alone system where the inverter output is not connected to a utility. If the backfed circuit breaker becomes disconnected from the panel, it will still be energized by the inverter. The 2011 NEC requires backfed circuit breakers in stand-alone mode, or utility interactive mode with stand-alone loads, to be secured with an additional fastener as required by 408.36(D) for plug-in-type overcurrent protection devices in other systems.

Question 94: Which circuit breaker listed below requires an additional fastener?

A: A back-fed plug-in type circuit breaker supplied by the inverter of a stand-alone PV system output circuit.
B: A back-fed bolt-in type circuit breaker in a stand-alone PV inverter output circuit.
C: A back-fed bolt-in type circuit breaker in a utility-interactive PV inverter output circuit.
D: A back-fed bolt-in type circuit breaker in PV source circuit.

## Question 95: 690.11 Arc-Fault Circuit Protection (Direct Current).

Question ID#: 220.0




***A listed DC arc-fault circuit interrupter will protect PV systems from series faults occurring in wiring between PV modules.***

PV systems that are mounted on a building or penetrate the building membrane and operate at a voltage of 80 volts or greater require a ***listed DC arc-fault circuit interrupter, PV type, or other system components listed to provide equivalent protection.*** The device must detect the fault and disable the components within the arcing circuit, such as battery charge controllers or inverters. The disconnected equipment must be manually restarted, and there must be a visual indication that the AFCI device has operated.

As of January 2011, there isn't currently a listed direct current AFCI device in existence. In fact, there is not even a UL standard for testing this device, although 1699B is expected in 2011. The device will most likely be located in the inverter or combiner box in a grid-tied system and in the charge controller of a battery based system. The protection will be for series faults that occur in the wiring between modules.

Question 95: Assuming that each PV DC module is rated 19 V, which of the following module arrays require arc-fault circuit protection? (Hint: a series string adds voltage but the current stays the same while a parallel connection adds current and the voltage stays the same.)

A: A single series string of 4 PV modules.
B: Two paralleled series strings of 4 PV modules.

C: A single series string of 5 PV modules.
D: Three paralleled series strings of 3 PV modules.

## Question 96: 690.13 Disconnecting Means. All Conductors.

Question ID#: 221.0


***Disconnects are required to separate all current-carrying DC conductors of PV systems from all other conductors in a facility.***

A disconnecting means is required to disconnect all current-carrying DC conductors from all other conductors in the building. A second disconnect on the AC, output side of the inverter is also required, but section 690.13 is about the DC disconnect.

All of the ungrounded DC conductors from the PV modules are disconnected by the required DC disconnect. The grounded DC conductor is not disconnected, except under ground-fault or arc fault conditions. A new exception has been added which allows the grounded DC conductor to be disconnected under the following conditions:

- The disconnect switch is used only for maintenance of the PV array.
- The disconnect switch is accessible to qualified persons only.
- The disconnect switch is rated for the maximum DC current and voltage possible during any operation.

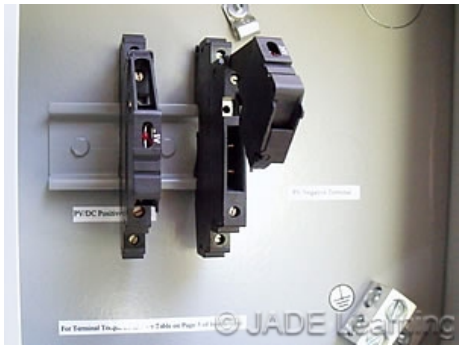
Permitting the grounded DC conductor to be disconnected from ground will be helpful for troubleshooting ground faults in the PV DC wiring. Maintenance personnel can check resistance to ground readings on conductors at several points on the PV system to help locate the ground fault.

Question 96: Which of the following locations in an office building complies with the NEC requirements for installation of a maintenance disconnecting means that disconnects the grounded conductor in a PV system?

A: A locked electrical room accessible to qualified personnel only.
B: A boiler room.
C: A mechanical room.
D: A janitor's closet.

## Question 97: 690.16(B) Fuse Servicing.

Question ID#: 222.0




***A disconnect must be located within sight of a fuse used to protect PV module strings.***

PV arrays that consist of only one or two strings do not require fusing on the PV output circuits. On PV output circuits that do require overcurrent devices, the disconnecting means must be located within sight of, and accessible to, the location of the fuse. This means that the disconnecting means must be within sight and not more than 50 feet away. However, for PV systems, if the disconnect is more than 6 feet away from the fuses, a directory is required to show the location of each disconnect.

Under the 2008 NEC, roof-mounted arrays often had a combiner box on the roof where the source circuits were paralleled to become output circuits. These conductors would then be run down to ground level or inside a garage where a DC disconnect was located next to the inverter. Because the DC disconnect for the PV output circuit fuses must now be within sight of the fuses, this is no longer acceptable.

There are two options: (1) Install a combiner box with an integrated DC disconnect or (2) install an external disconnect within sight of and accessible to the combiner box. This 2nd option may require running the circuits from the PV modules to within sight of the inverter and combining them there.

Question 97: Which of the following installations is a violation of the 2011 NEC?

A: A PV module circuit combiner box with fuses and an integrated DC disconnect.
B: A PV module circuit combiner box with fuses and an external disconnect mounted 15 ft. away from the combiner box with a directory indicating the location of the disconnect.
C: A PV module circuit combiner box with fuses mounted on the roof with the DC disconnect mounted inside a garage.
D: A PV module circuit combiner box that does not require fuses mounted on the roof with the DC disconnect mounted at grade level.

## Question 98: 690.31(E) Methods Permitted. Direct-Current Photovoltaic Source and Output Circuits Inside a Building.

Question ID#: 223.0

***Type MC metal-clad cable is now permitted as a wiring method when installing PV conductors in buildings.***

There are new requirements for installing PV conductors inside of buildings. MC metal-clad cable is now permitted as a wiring method. There are also four new sections:

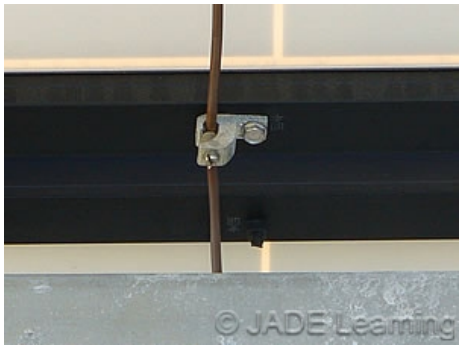
- Beneath Roofs. There are no specified distance requirements between roof decking or sheathing for any wiring methods installed beneath a roof as long as the wiring is directly under PV modules mounted on the roof. Wiring that is not installed directly under PV modules is permitted to be installed more than 10-inches below the roof decking or sheathing.
- Flexible Wiring Methods. FMC smaller than 3/4 in. and MC cable smaller than 1 in. shall have guard strips installed to protect the raceway or cable when run across ceilings or floor joists. The wiring methods shall closely follow the building surface.
- Marking or Labeling Required. Enclosures and wiring methods containing PV conductors shall be marked "Photovoltaic Power Source."
- Marking and Labeling Methods and Locations. Labels must be visible after installation. Labels must be installed no more than 10 ft. apart and are required to be suitable for the environment where they are installed.

Question 98: For PV source and output circuits ahead of the PV disconnecting means that are installed in an attic but NOT installed beneath a PV module, which of the following installations is permitted?

A: NM cable installed 8-inches from the roof decking.
B: AC-Cable installed at a right angle across the face of 6-inch roof rafters supporting the roof decking.
C: UF cable installed parallel to the ceiling joists 8-inches from the roof surface.
D: MC cable installed 11 inches from the roof decking.

## Question 99: 690.43 Equipment Grounding.

Question ID#: 224.0




***Non-current carrying metal parts of a PV system must be bonded together and connected to an equipment grounding conductor.***

All of the non-current carrying parts of a PV system must be bonded together and connected to an equipment grounding conductor. The metal frames of PV modules must be bonded together and to the mounting structure. All metal enclosures for PV equipment must be connected to the PV modules and mounting structure and bonded to the grounding system.

The entire section has been rewritten and reorganized into a list format for the 2011 NEC. Subsections (C) Structure as Equipment Grounding Conductor, and (D) Photovoltaic Mounting Systems and Devices are new.

(C) Devices are available that bond the module frame to an aluminum mounting rack. The mounting racks have been designed to support the PV modules, not act as equipment grounding conductors. Certain types of mounting racks are identified as an equipment grounding conductors, or can be used as an equipment grounding conductor by the use of identified bonding jumpers between separate metal sections of the mounting rack.
(D) Devices are available that will ground the module frame through the mechanical fasteners that hold the module to the supporting structure. These devices must be listed and identified for the purpose of grounding PV modules.

Question 99: Which of the following is a true statement about equipment grounding for PV systems?

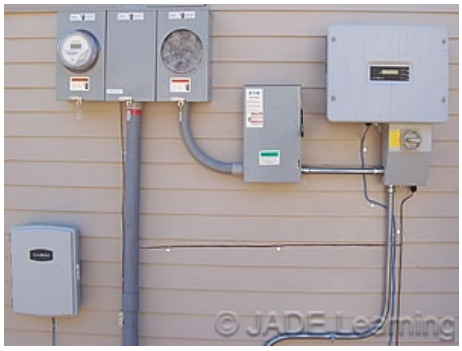
A: All types of module mounting frames can be used as an equipment grounding conductor.
B: Identified devices can be used to bond the PV module frames to the mounting rack.
C: Metal PV module frames are not required to be connected to an equipment grounding conductor.
D: A No. 10 AWG solid copper equipment grounding conductor is required to be installed between PV modules.

## Question 100: 690.47(C) Grounding Electrode System. Systems with AC and DC Grounding Requirements.

Question ID#: 225.0

Section 690.47(D), which required a separate grounding electrode for the DC side of a PV system was deleted, and 690.47(C) was rewritten to clarify the requirements for installing grounding electrodes and grounding electrode conductors for PV systems.

Basically there are three ways to connect a PV system to a grounding electrode: (1) Install separate grounding electrodes at the AC side of the system and the DC side of the system, and bond them together. (2) Use a common grounding electrode; the DC grounding electrode conductor can be bonded to the AC grounding electrode. (3) Connect a DC grounding electrode conductor to the AC equipment grounding terminal in the inverter.
The rewrite makes it much clearer that the DC grounding electrode and the AC grounding electrode must be bonded together. Also, it clarifies that a common grounding electrode can serve both the DC and AC side of a PV system.




***PV systems can be connected to a grounding electrode in 3 different ways.***

Question 100: Which of the following statements about connecting a grounding electrode to a PV system is true?

A: If a system has a DC grounding electrode, it must be bonded to the AC grounding electrode.
B: The DC grounding electrode is bonded to the PV modules but not to the AC side of the system.
C: A DC grounding electrode conductor is always required to connect to a DC grounding electrode.
D: The AC grounding electrode is isolated from the DC PV modules.

## Question 101: Article 694 Small Wind Electric Systems.

Question ID#: 226.0


***Small wind (turbine) electric systems are rated up to 100 kW.***

Article 694 is new to the 2011 NEC. The scope of the article in section 694.1 says:

***The provisions of this article apply to small wind (turbine) electric systems that consist of one or more wind electric generators with individual generators having a rated power up to and including 100kW. These systems can include generators, alternators, inverters, and controllers.***

Each tower-mounted wind turbine has an individual generator. The output of the single generator cannot be more than 100kW if it is to be regulated by Article 694. The separate wind turbine generators can be connected together to deliver large blocks of power to the utility grid.

A wind turbine uses a generator to create electricity. A windmill uses mechanical energy to perform work such as pump water.

An Informational Note at 694.1 explains:

***Small wind electric systems can be interactive with other electrical power production sources or might be stand-alone systems. Small wind electric systems can have ac or dc output, with or without electrical energy storage, such as batteries.***

Like solar photovoltaic systems, most small wind electric systems are connected to the utility grid and sell the power back to the utility operator.

Many of the requirements in Article 694, Small Wind Electric Systems are similar to the requirements in Article 690, Solar Photovoltaic (PV) Systems.

Question 101: Which of the following statements about small wind electric systems is true?

A: The output is always DC current.
B: The maximum rated output current cannot be more than 10 kW.
C: They can be installed as stand-alone or utility-interactive systems.
D: They cannot be connected to other sources of power.

## Question 102: 695.3 Power Source(s) for Electric Motor-Driven Fire Pumps.

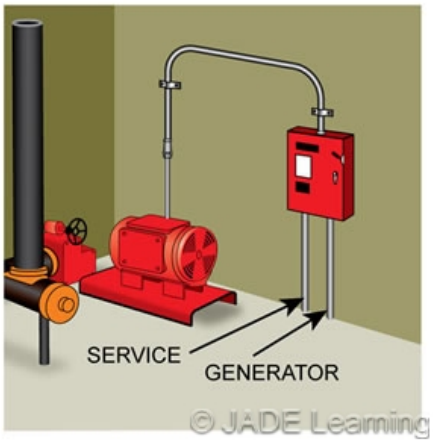
Question ID#: 227.0

Fire pumps are mission critical for the fire protection of buildings. The fire pump supplies water to the building sprinkler system, and it must continue to run under all conditions. The power source(s) for the fire pump must be as reliable as possible and supply power to the fire pump even if the building is disconnected from the utility. Section 695.3 has been rewritten to help clarify the requirements for how power is supplied to a fire pump.

A fire pump can be supplied by (1) a separate utility connection or a utility connection ahead of the service disconnecting means, (2) an onsite power production facility, such as a customer owned power plant, or (3) a dedicated feeder downstream of the service disconnect.

Fire pumps are permitted to have more than a single source of power. The most common arrangement is to have a connection to the utility (usually ahead of the service disconnecting means) and a connection to a standby generator. If a standby generator is used as an alternate source of power for the fire pump, it must have enough capacity to start the fire pump motor. Because the starting current for typical AC squirrel cage induction motors is approximately 6 times the motor's running current, a generator that is able to start the pump can easily supply its running current. Motors do not simultaneously pull both starting and running current. After the pump is started, the generator must be rated to carry its running current and any other loads that are operated simultaneously with the fire pump.

***For example:*** If a fire pump's full load current was 30 amps, the generator would have to be able to provide approximately 6 times its running current or 180 amps in order to start the pump motor. Motors do not draw starting and running current simultaneously; once the fire-pump is started its current drops to 30-A. If the stand-by generator can supply a starting current of 180-A, it can also supply any load less than 180-Amps. Because the pump's starting current is higher than its running current, if the generator is sized to carry the pump's starting current, it will easily carry its running current.




***Fire pumps are permitted to have multiple sources of power.***

Question 102: A fire pump is supplied by a standby generator. The fire pump has a full-load current of 18 amps, and a starting current of 108 amps. What is the required capacity of the standby generator in amps?

A: 27 amps.
B: 108 amps.
C: 135 amps.
D: 169 amps.

## Question 103: 695.4(B) Continuity of Power. Connection Through Disconnecting Means and Overcurrent Device.

Question ID#: 228.0


***Fire pumps must be protected from accidentally being disconnected from their power sources.***

Fire pumps must be protected from unintentionally being disconnected from the power source. Fire pump disconnects and overcurrent protection must be positioned, selected and installed so that all of the power sources connected to the fire pump will be available to run the fire pump.

The rewritten section has three major parts: (1) Number of Disconnecting Means. (2) Overcurrent Device Selection. (3) Disconnecting Means.

- Number of Disconnecting Means. The general rule is that a single disconnecting means is permitted between the power source and the fire pump controller or transfer switch. An additional disconnecting means is permitted for an on-site standby generator, or at each building in a multibuilding campus-style complex.
- Overcurrent Device Selection. The overcurrent protection for an individual source of power for the fire pump must be sized to carry the full locked-rotor current of the fire pump and any associated equipment. The overcurrent device for an on-site standby generator is sized to allow for instantaneous pickup of the full pump room load.
- Disconnecting Means. The fire pump disconnect must be suitable for use as service equipment, lockable in the closed position, and located remotely from the disconnecting means of other equipment. Disconnects for on-site standby generators are installed as part of emergency circuits and must be lockable. The fire pump disconnect and controller must be marked. The disconnect must be supervised by a central station or by other means.

Question 103: When a fire pump is connected through a disconnecting means, which of the following statements is true?

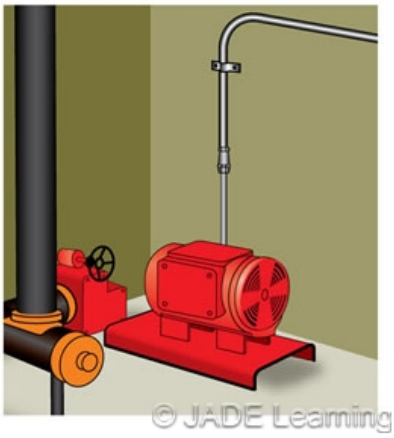
A: The overcurrent protection must be selected based on the locked-rotor current of the fire pump and any associated equipment.
B: The overcurrent protection for an on-site standby generator is selected based on the locked-rotor current of the fire pump equipment.
C: The overcurrent protection is based on the running full-load current of the fire pump.
D: The overcurrent protection is installed between the transfer switch and the fire pump.

## Question 104: 695.6 Power Wiring.

Question ID#: 229.0

This section has been rewritten and several new requirements have been added. For feeders on the load side of the final disconnecting means, and for conductors connected to an on-site generator, the conductors must be kept independent of all other wiring. The conductors shall supply only loads directly associated with the fire pump system. The conductors shall be protected from physical damage. Where routed through a building the conductors must be either encased in a minimum of 2 inches of concrete, be protected by a fire-rated assembly with a minimum 2 hour rating, or be a listed electrical circuit protective system with a minimum 2 hour rating.

Electrical metallic tubing is now an acceptable wiring method for wiring from the fire pump controller to the fire pump motor.
A number of requirements have been extracted from NFPA 20-2010 Standard for the Installation of Stationary Pumps for Fire Protection. These include sections on Listed Electrical Circuit Protective System to Controller Wiring, Junction Boxes, and Raceway Terminations. Where raceways are terminated at fire pump controllers, listed conduit hubs are required.



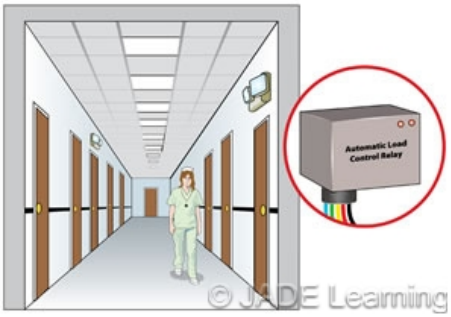

***EMT is now a permitted wiring method between the fire pump controller and the fire pump motor.***

Question 104: Which of the following is true for feeder conductors on the load side of the final disconnecting means?

A: Conductors cannot be installed inside of buildings.
B: Conductors can supply the fire pump system and other loads.
C: Conductors installed inside of buildings shall be encased in 2 inches of concrete or be protected by listed protective system with a 2-hour fire rating.
D: Conductors installed outside of buildings shall be encased in 2 inches of concrete.

## Question 105: 700.2 Emergency Systems. Relay, Automatic Load Control.

Question ID#: 230.0




***Automatic load control relays are permitted to supply emergency lighting.***

A new term for a device used to handle emergency lighting loads is now included in section 700.2. An Automatic Load Control Relay is:

***A device used to energize switched or normally-off lighting equipment from an emergency supply in the event of loss of the normal supply, and to de-energize or return the equipment to normal status when the normal supply is restored.***

This definition permits an emergency light to function as a dimmable or switched luminaire for normal area illumination while power is present and then during an outage, the relay overrides the switch to ensure that the emergency light remains on continuously until power is restored.

When normal power is restored, the automatic load control relay allows the luminaires to be controlled once again by a switch or dimmer.

Automatic load control relays are stand-alone devices specifically listed to transfer emergency power to lighting loads. Section 700.24 describes the permitted use of automatic load control relays. Load control relays are not transfer equipment that transfer power from the normal source to an emergency source. Load control relays energize lighting loads from an emergency source of power.

Question 105: Which of the following is a prohibited use of load control relays?

A: Used as a transfer switch for non-lighting emergency loads.
B: To supply emergency power to an emergency light.
C: To supply emergency power to a normal light.
D: To supply emergency power for both normal lighting and emergency lighting.

## Question 106: 700.10(D)(1) Wiring, Emergency System. Fire Protection. Feeder-circuit Wiring.

Question ID#: 231.0

***Requirements for emergency system feeder wiring for places of assembly have been clarified.***

Section 700.10(D)(1) describes the requirements for installing emergency wiring systems in occupancies used for ***"assembly, educational, residential, detention and correctional, business, or mercantile purposes."*** It applies to these occupancies only if they are designed for 1,000 people or more or are in buildings over 75 feet high. The 2011 NEC increased the fire rating for feeder-circuit wiring for emergency systems in these occupancies from 1 to 2 hours.

Feeder-circuit wiring for emergency systems in facilities affected by this change are required to comply with one of the following:

- To be protected by an approved automatic fire suppression system.
- To have a circuit protective system with a minimum 2 hour fire rating.
- To be provided with a listed thermal protective barrier having at least a 2 hour rating.
- To be installed in a fire rated assembly containing only emergency wiring having at least a 2 hour rating.
- To be encased in a minimum of 2 inches of concrete.

This change is designed to ensure that fire pumps, fire-service elevators, and emergency lighting will have emergency power for at least 2 hours. This additional time provides an increased margin of safety for firefighters and for those who are trying to escape large burning buildings.

Question 106: If it is not provided with a listed electrical circuit protective system with a 2 hour fire rating, which of the following is permitted to provide the required protection for a feeder-circuit for emergency lighting in a prison?

A: RMC in a 2 hour fire rated assembly containing emergency wiring and normal wiring.
B: RMC embedded in 4 inches of concrete.
C: RMC protected by an listed thermal protective barrier with a 1 hour rating.
D: RMC installed in an area which is not protected by an approved automatic fire suppression system or other means.

## Question 107: 700.12(F) Emergency Systems. General Requirements. Unit Equipment. Exception 2.

Question ID#: 232.0


***Emergency lighting outside an exit door can be supplied from the emergency lighting circuit inside the same exit door.***

A new exception permits emergency lighting on the outside of an exit door to be supplied from the emergency lighting circuit immediately inside the same exit door. The 2008 NEC required the lighting for the exterior of the exit door to be supplied by an outdoor lighting circuit.

The exception will allow the exit/emergency lights inside the door to supply remote lighting heads outside the exit door. It will make for a more efficient installation and still not compromise safety. When the normal power fails and the emergency lighting inside the exit door is energized, the outside emergency lighting will also be energized, providing illumination for people evacuating the building.

Unit equipment for emergency lighting is required to include the following:

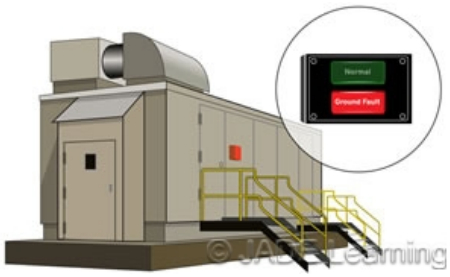
- A battery that is rechargeable.
- A means of recharging the battery.
- One or more lights mounted on the unit or terminals for remote lights. Units are also permitted to include mounted lights as well as terminals for remote heads.
- To be fixed (not portable).
- To automatically turn on if the normal power supply is interrupted.
- To be supplied by a branch circuit supplying normal lighting in the area where the unit is installed or to be supplied by a separate circuit from the same panel that supplies normal lighting circuits and to be equipped with a ***lock-on*** device.

Question 107: Which of the following violates requirements for unit equipment providing emergency illumination?

A: Interior unit equipment supplying lighting for the exterior side of an exit door.
B: Unit equipment including mounted lights but without terminals to supply remote lights.
C: Unit equipment illuminating the interior area adjacent to an exit door on the 3<sup>rd</sup> floor and supplying remote lights outside an exit door on the 1<sup>st</sup> floor.
D: Unit equipment illuminating the interior area adjacent to an exit door and also illuminating the area immediately outside that exit door with a remote light.

## Question 108: Article 701.6(D) Legally Required Standby Systems. Signals. Ground Fault.

Question ID#: 233.0




***An audible and a visual alarm is now required on legally required standby systems to indicate a ground-fault of 1200 amps or more.***

Legally required standby systems are installed to serve loads such as communications systems, ventilation and smoke removal systems, lighting, and industrial processes that could create a hazard if shut down. Legally required standby systems are different than emergency power systems which are required for life safety.

The 2008 NEC required both an audible and a visual signal device on legally required standby systems to indicate:

- That the standby source was deranged.
- That the standby source was carrying load.
- That the battery charger was not functioning.

The 2011 NEC now also requires an audible and a visual signal device to be provided where practicable on legally required standby systems to indicate that the ground-fault detection system has detected a ground-fault of 1200 amps or more. This change also requires that instructions be posted on or near the sensor location indicating the course of action to take when a ground-fault is detected.

Typical instructions may require a qualified person to contact the person in charge of emergency personnel in the facility to determine whether or not the system should be manually shut down or to let it continue to provide power for emergency operations in spite of the ground-fault indication.

Question 108: Which of the following is required for legally required standby systems?

A: The system is required to remove all ungrounded conductors when sensing a ground-fault of 1200 amps or more.
B: A sign indicating the course of action to take in the event the system indicates it has detected a ground-fault is required to be posted near or on the sensor.
C: The system is required to remove all ungrounded conductors when sensing a ground-fault in excess of 1000 amps.
D: Either an audible or visual signal is required to indicate a ground-fault has been detected.

## Question 109: 705.6 Interconnected Electric Power Production Sources. System Installation.

Question ID#: 234.0


***Installing utility-interactive output devices should be done by qualified persons only.***

Examples of interconnected electric power production sources are solar PV systems, wind generators, fuel cells and battery banks that have a connection to the electric utility. They operate in parallel with the utility and can generate their own power to supply loads, or they can sell power back to the utility.

Installing utility-interactive output devices such as DC to AC inverters, other control devices, and wiring that is supplied by an alternate power source and interconnected with a primary power source is complicated. It is not a job for a handyman or home owner.

Section 705.6 requires power systems that will be operated in parallel with a primary source of electricity to be installed by qualified persons.
Article 100 defines a qualified person ***as "One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved."***

Question 109: If they have the required licenses, who is qualified to install a wind generator that will operate in parallel with a source of power supplied by a utility company?

A: An electrical apprentice.
B: An electrical engineer.
C: A mechanical engineer.
D: A person trained to install the system who can recognize the safety hazards.

## Question 110: 705.12(A) Interconnected Electric Power Production Sources. Point of Connection. Supply Side.

Question ID#: 235.0

Alternate power production sources, such as solar PV systems, fuel cells, and small wind electric systems, are permitted to be connected to the supply side of the service. A new sentence in the 2011 NEC requires the sum of the ratings of all overcurrent devices connected to the alternate power production sources to not be greater than the rating of the service.
For example, without this new requirement, two, 60 amp utility-interactive inverters could be connected to a 100 amp panel. A 60 amp inverter is capable of producing 60 amps of AC current on the output side. Two, 60 amp inverters could produce 120 amps, and this is more than the rating of a 100 amp panel. Two, 50 amp inverters connected to the supply side of a 100 amp service panel is acceptable. Any combination of overcurrent device ratings from an alternate power production source is acceptable as long as the sum of the ratings of all overcurrent devices on the supply side of the service is not greater than the rating of the service.


***The rating of the overcurrent devices connected to alternate power production sources cannot exceed the rating of the service.***

Question 110: Which of the following installations of power production sources is not permitted to be connected to the supply side of a service disconnect?

A: The output from an inverter that is protected by four 10 amp fuses connected to the supply side of the disconnect for a 100 amp service panel.
B: The output from a battery bank and inverter that is protected by seven 15 amp fuses connected to the supply side of the disconnect for a 100 amp service panel.
C: One two-wire 120-V circuit supplied by a fuel cell protected by a 30 amp fuse connected to the supply side of the disconnect for a 100 amp service panel.
D: The output of a 240-V, 20-kVA single-phase generator protected by a 100 amp circuit breaker connected to the supply side of the disconnect for a 200 amp panel.

## Question 111: 708.10(A)(2)(Ex.) COPS. Feeder and Branch Circuit Wiring. Receptacle Identification.

Question ID#: 236.0

Article 708 specifies the requirements for Critical Operations Power Systems (COPS). COPS are defined as power systems for facilities or parts of facilities that require continuous operation for the reasons of public safety, emergency management, national security or business continuity. Designated Critical Operations Areas (DCOA) are areas within a facility or site designated as requiring critical operations power.

Critical Operations Power Systems are designed to supply electrical power to Designated Critical Operations Areas for HVAC, fire alarm, security, communications, and signaling systems as well as for general power distribution within the facility.

In buildings where Critical Operations Power Systems are present with other types of wiring, the receptacles or the receptacle plates for the COPS systems must have a distinctive marking or color to make them readily identifiable.
A new exception has been added which says that if the COPS supplies power to a DCOA that is a stand-alone building, receptacle cover plates or the receptacles themselves are not required to have the distinctive marking or color.


***COPS supplied receptacles must be distinguished from receptacles of other systems.***

Question 111: Which of the following installations supplied by COPS is required to have the receptacles or receptacles covers identified by a distinctive marking or color?

A: A DCOA located in a stand-alone building where all power is supplied by COPS.
B: A building designated exclusively as a DCOA where all power is supplied by COPS.
C: A building with several power systems that has one floor assigned as a DCOA and the rest of the building used for other purposes.
D: A DCOA where all power is supplied by COPS located in a stand-alone building on a military base.

## Question 112: 708.14 COPS Wiring of HVAC, Fire Alarm, Security, Emergency Communications, and Signaling Systems.

Question ID#: 237.0

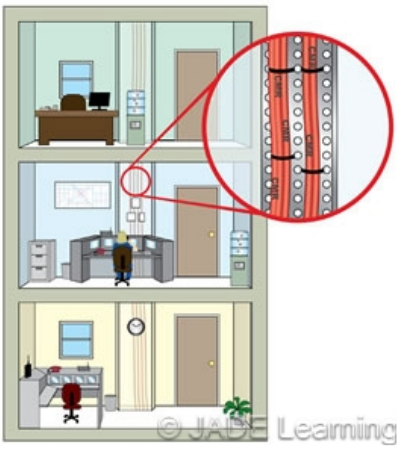
Wiring for Critical Operations Power Systems supplying HVAC, Fire Alarm, Security, Emergency Communications, and Signaling Systems is required to be installed using a metallic wiring method. Permitted metallic wiring methods include the following:

- RMC, IMC, and MI-cable.
- EMT and jacketed metallic raceways encased in at least 2 inches of concrete.
- Flexible metal conduit with listed fittings and liquidtight flexible metal conduit with listed fittings is permitted where flexibility is required.

Circuits installed for HVAC, Fire Alarm, Security, Emergency Communications, and Signaling Systems are required to comply with the following conditions:

- Fire alarm, security, signal systems, and emergency communications are required to be installed using twisted pair cables with a continuous shield.
- Fiber-optic cable is required for connections between buildings managed by the same agency.
- Conductors used in control circuits exceeding 50 V are required to be rated for at least 600 V.
- Relays used in communications, fire alarm, and signaling circuits are required to have contacts rated in excess of the current and voltage of the control circuit.

In the 2011 NEC, cables used in fire alarm, security, and signaling systems must be a riser-rated, listed 2 hour electrical circuit protective system. Riser emergency communication cables are required to be Type CMR-CI or to be a listed 2 hour electrical circuit protective system.




***Wiring methods permitted for COPS areas are limited to methods listed in Article 708.***

Question 112: Which of the following installations in a Designated Critical Operations Area is a Code violation?

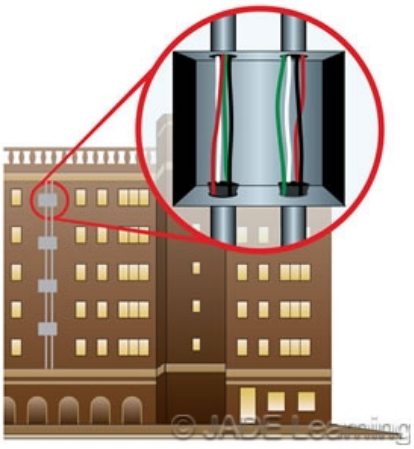
A: Fire alarm system cables installed using a listed 2 hour electrical circuit protective system.
B: Security system cables installed using Type CMR-CI cables.
C: Emergency communications installed using stranded No. 18 AWG THHN conductors installed in RMC.
D: Emergency communications using twisted pair cables with a continuous shield installed in EMT encased in 3 inches of concrete.

## Question 113: 725.3(I) Vertical Support for Fire-Rated Cables and Conductors.

Question ID#: 238.0

***Article 725 covers Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits that are not an integral part of equipment. These circuits are commonly used with*** burglar alarm and ***security systems, intercom and nurse-call stations, computer networking systems, and control circuits for luminaire dimmers.***

Section 725.3 says only those sections of Article 300 that are referenced in Article 725 apply to ***Class 1, Class 2, and Class 3 circuits.*** Requirements for vertical installations of fire-rated circuit integrity (CI) cables and conductors are described in 725.3(I) which requires them to be supported at intervals not exceeding the requirements in Table 300.19(A). When exposed to the high temperatures that occur in fires, the strength of cables and conductors is significantly reduced. In vertical runs, if they are not adequately supported, the cables may be pulled apart by their own weight disrupting the operation of fire alarm systems.
Section 300.19(B) requires that vertical installations of fire-rated cables and conductors comply with provisions of the listing for electrical circuit protective systems. This section also requires that the distance between supports for vertical installations are not to exceeded the distances in Table 300.19(A).




***Support for vertical runs of fire-rated cables and conductors is required.***

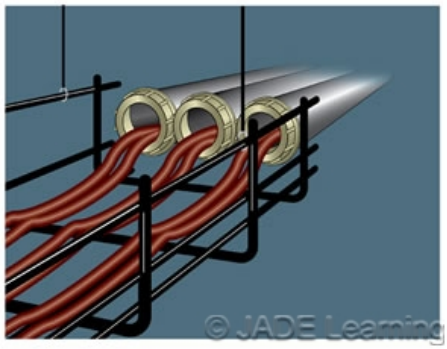
Question 113: What is the maximum distance between vertical supports for fire-rated No. 8 AWG copper conductors installed in a raceway?

A: 25 feet.
B: 30 feet.
C: 80 feet.
D: 100 feet.

## Question 114: 725.3(J) Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits. Bushing.

Question ID#: 239.0

When cables and conductors are installed in raceways for physical support and/or protection, section 725.3(J) requires that a bushing be installed on the raceway to protect the cable from abrasion as required by 300.15(C). However, 300.15(C) only requires that a fitting be used to provide protection from abrasion. ***The fitting could be either a bushing or other listed fitting that provides the required protection***.
Section 760.3(K) requires that cable systems used for fire alarm systems be protected in the same manner.
Raceways used as sleeves to provide physical protection for cables and conductors are not required to be terminated in a box or conduit body. However, if a raceway used as a sleeve does not terminate in an enclosure, a bushing or other listed fitting is still required to be installed on the end of the raceway to protect cables and conductors from abrasion. A bushing or other fitting is also required when raceways containing cables or conductors are terminated on boxes or enclosures. For example, in vertical raceways where cables are supported in an enclosure by ***off-set*** cleats, a bushing or other fitting is required on the ends of the raceway where the cable enters and exits the enclosure.



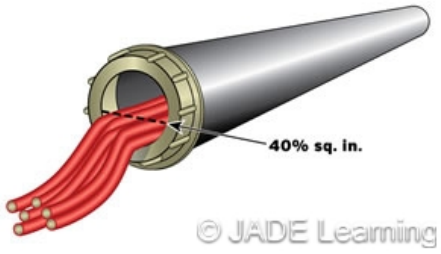

***Cables and conductors used in Class 1, 2, and 3 circuits are required to be protected by bushings when exiting raceways.***

Question 114: Which of the following does not require a bushing to be installed on the end of a raceway to prevent a cable from being damaged by abrasion?

A: A vertical installation of a fire-rated CI-cable installed in RMC secured to a junction box where an off-set arrangement of cleats provides mechanical support for the cable.
B: A horizontal installation of a fire-rated CI-cable installed in RMC secured to an enclosure with a listed fitting that already has an integral insulated bushing.
C: A horizontal run of IMC used as a sleeve to protect a fire-rated CI-cable.
D: A horizontal installation of a fire-rated CI-cable installed in RMC secured to a junction box.

## Question 115: 760.3(J) Fire Alarm Systems. Number and Size of Cables and Conductors in Raceway.

Question ID#: 240.0




***The conductors installed in raceways for fire alarm systems are not permitted to exceed the percentage fill permitted in Table 1, Ch. 9.***

Section 760.3(J) limits the number and size of conductors and cables permitted in raceways for fire alarm systems and requires installations to comply with 300.17. Raceways permitted for fire alarm systems all require that the size and number of conductors in a raceway not exceed the percentage fill permitted in Table 1, Chapter 9.

The area of a multiconductor cable is used when determining the allowable percentage of raceway fill in accordance with Table 1 in Chapter 9. However, because Chapter 9 does not include information on fire alarm cables, this information has to be obtained from product listing data or from the manufacturer. If you know the area of a fire alarm cable, you can use Table 1 (page 711) and Table 4 (page 714 for RMC) in Chapter 9 to determine the minimum size raceway required for the cable.

For example, on page 714, using RMC and one cable with an area of .375 sq. inches:

- Find the column for 1 wire (53% fill).
- In this column find the smallest fill area in sq. inches that equals or exceeds the .375 sq. inch area of the sample cable.
- The smallest fill area in the 53% column that exceeds the area of the cable is .470 sq. inches.
- In that row, the far left column indicates the minimum size RMC that can be used for the cable is 1 inch RMC.

If a raceway has more than one cable, add the area of all cables and then use the appropriate fill column (31% for 2 wires or 40% for over 2 wires). Select the smallest raceway that has an allowable fill area equaling or exceeding the total area of the cables.

Question 115: If a single multiconductor cable for a fire alarm system has a cross-sectional area of .45 sq. inches, what is the minimum size raceway permitted if 3 cables are installed in RMC? (Hint: Use the over 2 wires, 40% column.)

A: 1 1/4 inch RMC.
B: 1 1/2 inch RMC.
C: 2 inch RMC.
D: 2 1/2 inch RMC.

## Question 116: 760.41 Fire Alarm Systems. NPLFA Circuit Power Source Requirements. Branch Circuits.

Question ID#: 241.0


***Branch circuits supplying fire alarm equipment are not permitted to supply other loads.***

The 2008 NEC required an individual branch circuit to supply fire alarm systems. This was too strict because of the limited power consumed by these systems.

The 2011 NEC now requires that ***"The branch circuit supplying the fire alarm equipment(s) shall supply no other loads."*** The revision means that a single branch circuit is permitted to supply more than one fire alarm system or component; however, it is not permitted to supply any other type of equipment.

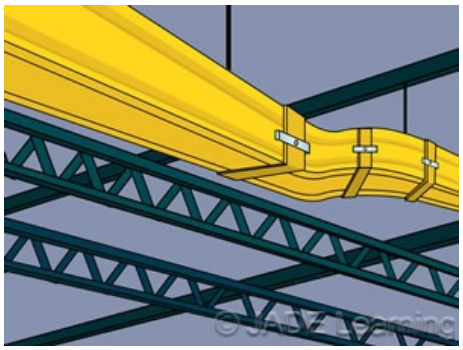
The location of the branch circuit overcurrent protective device for fire alarm systems is required to be permanently identified at the fire alarm control panel. The branch circuit for a fire alarm system is not permitted to be supplied from an arc-fault circuit-interrupter or a ground-fault circuit-interrupter. The circuit disconnecting means is required to be identified by permanent red marking that does not obscure the manufacturer's markings; and, it is required to be identified as the "FIRE ALARM CIRCUIT." The disconnecting means shall be accessible only to qualified personnel.

Question 116: Which of the following is permitted as the power source for fire alarm systems?

A: A circuit breaker that supplies the fire alarm system and a phone system.
B: A GFCI circuit breaker that supplies a single fire alarm system.
C: An AFCI circuit breaker that supplies two fire alarm systems.
D: A single circuit breaker that supplies two fire alarm panels.

## Question 117: 770.2 Optical Fiber Cables and Raceways. Definitions. Cable Routing Assembly.

Question ID#: 242.0




***Cable routing assemblies are now permitted to be used for installing communication and data cables.***

The 2011 NEC includes a new term in section 770.2 to define a Cable Routing Assembly for optical fiber cables***: "A single channel or connected multiple channels, as well as associated fittings, forming a structural system that is used to support, route and protect high densities of wires and cables, typically communications wires and cables, optical fiber and data (Class 2 and Class 3) cables associated with information technology and communications equipment."***

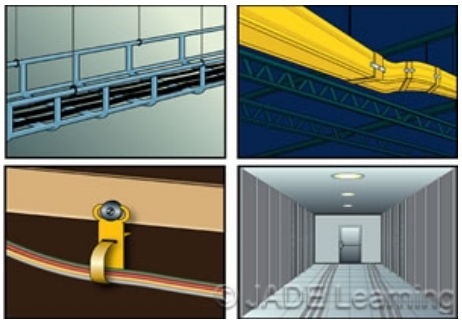
The definition uses the word "channel" in order to avoid confusing a Cable Routing Assembly with a cable tray or raceway. The definition of the new term complies with the installation requirements for optical fiber cable routing assemblies that are located in sections 770.113 and 770.154.
According to the proposal for this Code change, cable routing assemblies are U-shaped and may or may not have covers. Cable routing assemblies are larger than raceways and unlike raceways are of open construction. During a fire the open construction of a cable routing assembly exposes the fiber optic cable to high temperatures and flames.

Question 117: Which of the following is not identified as one of the types of cables or conductors typically installed in an optical fiber cable routing assembly?

A: Communications wires and cables.
B: Class 1 remote-control and signaling cables.
C: Optical fiber and data Class 2 communications cables.
D: Optical fiber and data Class 3 information technology cables.

## Question 118: 770.113 Optical Fiber Cables and Raceways. Installation of Optical Fiber Cables and Raceways, and Cable Routing Assemblies.

Question ID#: 243.0



***Installation requirements for optical fiber cables and raceways, and cable routing assemblies are found in Article 770.***

Section 770.113 was revised by moving the installation requirements which were located in the applications section of Article 770 in the 2008 NEC to the installation section. The information on installation methods and applications was combined and simplified in Table 770.154(a) which identifies which cables are permitted in various parts of buildings and which installation methods are permitted in these locations. Similar revisions were made in sections 800.113 and 800.154.

In general, section 770.113 requires optical fiber cables, raceways, and cable routing assemblies installed in buildings to be listed. The section also lists the types of cables which are permitted to be installed in the following locations:

- Fabricated Ducts Used for Environmental Air
- Other Spaces Used for Environmental Air (Plenums)
- Risers in Vertical Runs, Metal Raceways, Fireproof Shafts, One and Two Family Dwellings
- Cable Trays
- Distribution Frames and Cross-Connect Arrays
- Other Building Locations

This same information is presented in a table format in Table 770.154(a).

Question 118: Which of the following types of cables is not permitted to be installed in other space used for environmental air (plenum)?

A: OFNP exposed.
B: OFCP exposed.
C: OFNR in a raceway.
D: OFNG exposed.

## Question 119: 770.154 Optical Fiber Cables and Raceways. Applications of Listed Optical Fiber Cables and Raceways, and Cable Routing Assemblies.

Question ID#: 244.0

***Table 770.154(a) is a guideline for installing optical fiber cable.***

Section 770.154 identifies four different areas within buildings where different types of optical fiber cables and installation methods are permitted:

- Fabricated ducts
- Other spaces used for environmental air
- Risers or vertical runs.
- Areas not used for either air-handling or risers

Table 770.154(a) simplifies the identification of the installation methods and cables permitted in each different area. In the table a "Y" indicates a permitted application and "N" indicates a non-permitted application. The permitted applications are required to be installed in accordance with the provisions of 770.110 and 770.113.

The installation methods required vary with the location. For example, any raceway permitted in Chapter 3 is permitted in areas of a building that are not used for air-handling or risers. However, only metal raceways or several different types of optical fiber routing assemblies are permitted in a riser.

Types of cables permitted vary depending on both location and on the installation method that is used. Table 770.179 identifies marking for eight types of optical fiber

cables: OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC.

- OF = optical fiber cable
- N = a non-conductive cable
- C = a conductive cable
- R = a riser rated cable
- P = a plenum rated cable
- G = general purpose cable

For example, a cable marked OFCR is a conductive optical fiber cable rated for risers. A cable marked OFNG is a non-conductive general purpose optical fiber cable. Listed plenum and riser rated cables are designed to minimize the potential for smoke and fire in areas where they are installed.

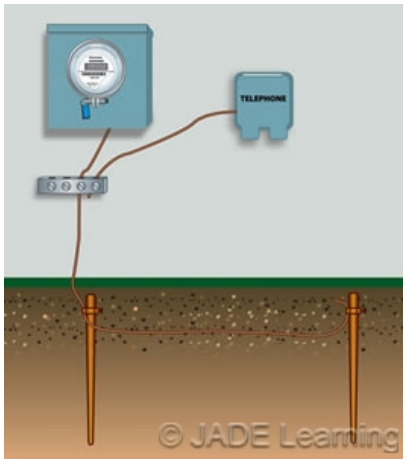
Question 119: When installed as required by 770.100 and 770.113, which of the following cables is permitted to be installed in a riser if the cable is installed using a riser cable routing assembly?

A: OFNG.
B: OFCG.
C: OFNR.
D: OFC.

## Question 120: 800.100 Communications Systems. Cable and Primary Protector. Bonding and Grounding.

Question ID#: 245.0

Bonding non-current carrying parts of communications systems to the grounding electrode system minimizes the potential for damage to equipment and injury to personnel caused by voltages differences produced by lightning strikes and equipment failures.



***Communications systems must be grounded.***

The primary protector and all metallic members of communications cable sheaths are required to be bonded and grounded to either an intersystem bonding termination, the power grounding electrode system in accordance with 250.52, or in buildings without a grounding means to an electrode permitted by 250.52(A).

Bonding and grounding conductors are permitted to be stranded or solid, insulated, covered, or bare. They must be listed and made of copper or other corrosion resistant material. The minimum size is No. 14 AWG. Their ampacity is required to equal or exceed the current carrying capacity of the grounded metallic member of communications cables, but they are not required to be larger than No. 6 AWG. They are required to be installed as short and as straight as possible and to be protected if subject to physical damage.

In one- and two-family dwellings, the maximum permitted bonding or grounding conductor length is 20 feet. An exception permits bonding to a driven communications system ground rod or pipe that is bonded to the power grounding electrode system with a No. 6 AWG or larger copper conductor.

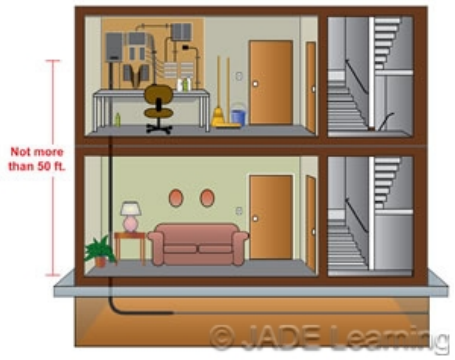
Question 120: In a site built, single family dwelling where the distance between the primary protector and the power grounding electrode system exceeds 25 feet, a communications system ground rod is installed. Which of the following is permitted to be used to connect the communications grounding rod to the power grounding electrode system?

A: An insulated, solid No. 6 AWG aluminum conductor.
B: A bare, solid No. 4 AWG copper conductor.
C: No. 14 AWG copper conductor.
D: An insulated, stranded No. 8 AWG copper conductor.

## Question 121: 800.113 Communications Systems. Installation of Communications Wires, Cables and Raceways.

Question ID#: 246.0

In general, section 800.113 requires communications cables, wires, and raceways installed in buildings to be listed. However, if not installed in risers, ducts, plenums, or spaces used for environmental air, an exception permits up to 50 feet of unlisted communication cable to be installed from the ***point of entrance*** to a listed primary protector or an enclosure. This exception permits unlisted underground cables used by communications utilities to enter buildings.




***The requirements for installing communications cables inside of buildings and structures have been clarified.***

Some types of cable are permitted to be installed in metal raceways in risers that are fire-stopped at each floor. Other types are listed for installation in cable tray. Cables and installation methods installed in risers, plenums, and spaces for handling environmental air are required to be listed for these locations and designed to resist spread of fire and toxic fumes. ***"Communications raceway"*** is a new term defined in section 800.2 as a closed non-metallic channel; different types are listed for installation in plenums, risers, or general applications.

Section 800.113 was revised providing more detailed information on the installation requirements for communication wires, cables, raceways, and cable routing assemblies. Sections B through L identify different locations in buildings and different types of buildings where communication cables are permitted to be installed. This same information is presented in an easy to understand table format in Table 800.154(a).

Question 121: Which of the following is permitted when installing an unlisted communications cable in a building from the point of entrance to a listed primary protector?

A: Installing 35 feet of the cable in a plenum.
B: Installing 60 feet of the cable in an area not used for handling air or a riser.
C: Installing 20 feet of the cable in a duct for environmental air.
D: Installing 50 feet of the cable in an area not used for handling air or a riser.

## Question 122: 800.154 Communications Systems. Applications of Listed Communications Wires, Cables, and Raceways.

Question ID#: 247.0

Similar to section 770.154 for listed fiber optical cables and raceways, section 800.154 and Table 800.154(a) identify four different areas within buildings where different types of communications cables and wiring methods are permitted:

- Fabricated ducts
- Other spaces used for environmental air
- Risers or vertical runs
- Areas not used for either air-handling or risers


***Wiring methods and materials change according to the area of the building where they are installed.***

Table 800.154(a) identifies the installation methods and cables permitted in each different area; in the table "Y" indicates a permitted application and "N" indicates a non-permitted application.

The installation methods permitted vary with the location. For example, any raceway permitted in Chapter 3 is permitted in areas of a building that are not used for air-handling or risers. However, only metal raceways are permitted in risers and areas used for environmental air. Several different types of communication cables and routing assemblies are listed for risers and in plenums. A number of different types of communications raceways are listed for different areas in a building. Because communications cables do not carry enough current to produce significant

amounts of heat, fill requirements in Chapters 3 and 9 do not apply to communications cables or wires.

Table 800.179 identifies marking for six types of communication cables:

- CMP = communication plenum cable
- CMR = communication riser cable
- CMG & CM = communication general purpose cable
- CMX = communication limited use cable
- CMUC = under carpet communication wire & cable

Question 122: When installed as required by 800.100 and 800.113, which of the following cables is not permitted to be supported by a cable tray when installed in a building in an area that is not a riser and that is not used for handling air?

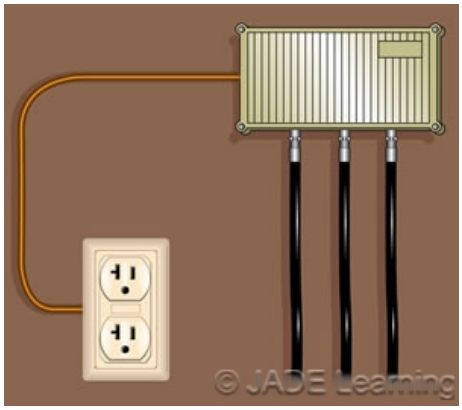
A: CMP.
B: CMR.
C: CM.
D: CMUC.

## Question 123: Article 820.100 Exception. Community Antenna Television and Radio Distribution Systems. Cable Bonding and Grounding.

Question ID#: 248.0

The general rule in section 820.100 requires the shield of coaxial cable to be bonded and grounded. These requirements are similar to the requirements in Article 800 for bonding and grounding communications cables. However, an exception in the 2011 NEC permits the cable shield to be connected to any of the equipment grounding conductors permitted in 250.118 where the cable is electrically isolated from the outside cable plant:

***Exception: For communications systems using coaxial cable confined within the premises and isolated from outside cable plant, the shield shall be permitted to be grounded by a connection to an equipment grounding conductor as described in*** 250.118. ***Connecting to an equipment grounding conductor through a grounded receptacle using a dedicated grounding conductor and permanently connected listed device shall be permitted. Use of a cord and plug for the connection to an equipment grounding conductor shall not be permitted.***




***When CATV cable is isolated from outside cable it can be connected to an equipment grounding conductor from the interior wiring.***

Grounding through a cord and plug connection is not permitted because unplugging the cord would break the grounding connection. The exception applies only to coaxial cable that is entirely confined inside a building and that is electrically isolated from all outside cable. Because the coaxial shields of isolated cables are not connected to cables outside the premises, they do not need to be protected against lightning and power crossover like cables that enter a building from an outside cable network.

Question 123: Which of the following statements about bonding and grounding the sheath of coaxial cable that is entirely within a building and is electrically isolated from outside coaxial cables is correct?

A: It is permitted to be cord and plug connected to an equipment grounding conductor.
B: It is required to be cord and plug connected to an equipment grounding conductor.
C: It is not required to be grounded.
D: It is permitted to be grounded by connection to any equipment grounding conductor permitted in 250.118 to an intersystem bonding terminal.

## Question 124: Article 840 Premises-Powered Broadband Communications Systems.

Question ID#: 249.0

Article 840 is a new article for premises-powered optical fiber-based broadband communications systems which are used to provide voice, video, data, and/or interactive services through an Optical Network Terminal (ONT).

An Informational Note in 840.1 describes a typical premises-powered broadband system as one that is supplied by an optical fiber cable with premises based equipment that converts optical input to electrical signals that can provide electrical input to internet connected PCs, telephones, and/or video equipment.

The incoming optical cable is not a source of power. The power for the equipment that converts the optical input to an electrical output signal is supplied by the premises electrical system or by a battery powered back-up. Some coaxial cables are non-conductive; others have conductive metallic shields and/or wire used to provide physical support.

Conductive cable shields supplying an optical network terminal are required to be grounded. However, the communication circuits themselves are not required to be grounded. An optical network terminal itself is only required to be grounded if its listing requires it.


***Article 840, Premises-Powered Broadband Communications Systems, is a new Article.***

Question 124: Which of the following statements about premises-powered optical fiber-based broadband communications system optical network terminals is correct?

A: An ONT is never required to be grounded.
B: An ONT is always required to be grounded.
C: When an ONT is required to be grounded, the size of the equipment grounding conductor is based on Table 250.66.
D: The metal shield of a coaxial cable connected to an ONT is required to be grounded.

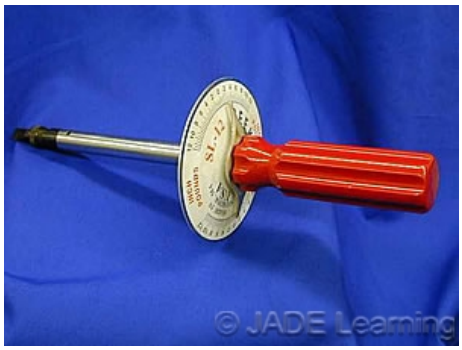
## Question 125: Informative Annex I Recommended Tightening Torque Tables from UL Standard 486A-B.

Question ID#: 250.0

Informative Annex I, like the other Annexes in the 2011 NEC, is not part of the requirements of the Code. It is included for informational purposes only. The torque tables are to be used in the absence of manufacturer's instructions on the equipment.

There are three tables in Annex I. Table I.1, Tightening Torque for Screws. Table I.2, Tightening Torque for Slotted Head Screws Smaller Than No. 10 Intended for Use with 8 AWG or Smaller Conductors. Table I.3, Tightening Torque for Screws with Recessed Allen or Square Drives.

Each Table has the metric measurement and the standard measurement (inside parenthesis). The standard measurements are read as inch-pounds. The Tables are taken from UL Standard 486 A-B. The values from both the A and B Standard are given, with separate A and B columns. The B column lists tighter torque values. Table I.1 and I.2 are divided by the slot width or slot length of the screw. A separate section of Table I.1 is for connectors with hexagonal heads. Use the left hand column in Table I.1 to select a connector based on the size of the wire in the connector. Read across the table to find the correct torque. For example, the suggested torque for a split-bolt connector used with 2/0 conductors is 385 inch-pounds, from the B column.




***Annex I provides torque specifications for screws and recessed Allen or square drives.***

Question 125: What is the required torque for a split-bolt connector with a hexagonal head that is used for No. 1 AWG conductors? Use the B column.

A: 165 inch-pounds.
B: 275 inch-pounds.
C: 300 inch-pounds.
D: 375 inch-pounds.

**Answer Sheet** **Darken the correct answer. Sample: A ● C D**

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| | | | | | | |
|---|---|---|---|---|---|---|
| 1.) A B C D | 19.) A B C D | 37.) A B C D | 55.) A B C D | 73.) A B C D | 91.) A B C D | 109.) A B C D |
| 2.) A B C D | 20.) A B C D | 38.) A B C D | 56.) A B C D | 74.) A B C D | 92.) A B C D | 110.) A B C D |
| 3.) A B C D | 21.) A B C D | 39.) A B C D | 57.) A B C D | 75.) A B C D | 93.) A B C D | 111.) A B C D |
| 4.) A B C D | 22.) A B C D | 40.) A B C D | 58.) A B C D | 76.) A B C D | 94.) A B C D | 112.) A B C D |
| 5.) A B C D | 23.) A B C D | 41.) A B C D | 59.) A B C D | 77.) A B C D | 95.) A B C D | 113.) A B C D |
| 6.) A B C D | 24.) A B C D | 42.) A B C D | 60.) A B C D | 78.) A B C D | 96.) A B C D | 114.) A B C D |
| 7.) A B C D | 25.) A B C D | 43.) A B C D | 61.) A B C D | 79.) A B C D | 97.) A B C D | 115.) A B C D |
| 8.) A B C D | 26.) A B C D | 44.) A B C D | 62.) A B C D | 80.) A B C D | 98.) A B C D | 116.) A B C D |
| 9.) A B C D | 27.) A B C D | 45.) A B C D | 63.) A B C D | 81.) A B C D | 99.) A B C D | 117.) A B C D |
| 10.) A B C D | 28.) A B C D | 46.) A B C D | 64.) A B C D | 82.) A B C D | 100.) A B C D | 118.) A B C D |
| 11.) A B C D | 29.) A B C D | 47.) A B C D | 65.) A B C D | 83.) A B C D | 101.) A B C D | 119.) A B C D |
| 12.) A B C D | 30.) A B C D | 48.) A B C D | 66.) A B C D | 84.) A B C D | 102.) A B C D | 120.) A B C D |
| 13.) A B C D | 31.) A B C D | 49.) A B C D | 67.) A B C D | 85.) A B C D | 103.) A B C D | 121.) A B C D |
| 14.) A B C D | 32.) A B C D | 50.) A B C D | 68.) A B C D | 86.) A B C D | 104.) A B C D | 122.) A B C D |
| 15.) A B C D | 33.) A B C D | 51.) A B C D | 69.) A B C D | 87.) A B C D | 105.) A B C D | 123.) A B C D |
| 16.) A B C D | 34.) A B C D | 52.) A B C D | 70.) A B C D | 88.) A B C D | 106.) A B C D | 124.) A B C D |
| 17.) A B C D | 35.) A B C D | 53.) A B C D | 71.) A B C D | 89.) A B C D | 107.) A B C D | 125.) A B C D |
| 18.) A B C D | 36.) A B C D | 54.) A B C D | 72.) A B C D | 90.) A B C D | 108.) A B C D | |

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