Commercial & Industrial Wiring (2014 NEC) (Homestudy)

Alaska Electrical Journeyman License

This course will review the 2014 National Electrical Code requirements for installing commercial and industrial wiring systems and equipment. Topics covered will include branch circuits and feeders, services, overcurrent protection, grounding and bonding, wiring methods and materials, switchboards and panelboards, motors, motor circuits, and motor controllers, generators, transformers, and industrial machinery.

Course# 15190 8 Industry Related Credit Hours $90.00

This course is currently approved by the Alaska Division of Labor Standards and Safety, Mechanical Inspection under course number 15190.

Completion of this continuing education course will satisfy 8.000 credit hours of course credit type 'Industry Related' for Electrical Journeyman license renewal in the state of Alaska. Course credit type 'Industry Related'. Board issued approval date: 3/1/2016. Board issued expiration date: 12/31/2017.

JADELearning

Commercial & Industrial Wiring (2014 NEC) (Homestudy) - AK

Introduction

Question 1: 90.1 Purpose.

Question ID#: 10512.0

The NEC provides practical requirements for electrical systems and installations to safeguard persons and property.

The National Electrical Code (NEC) is a uniform code owned and maintained by the National Fire Protection Association (NFPA). The first NECÂ® was adopted in 1897. The NEC is prepared by National Electrical Code Code-Making Panels and updated every three years. It is used in both the United States and other countries and is the most widely adopted electrical standard in the world.

The purpose of the NEC is to protect the public from the hazards of shock and fire. It has helped to dramatically reduce the number of deaths in the US from fire and electrocution. The NEC is a minimum Code and does not take into consideration future expansion or what is the most convenient or efficient installation.

The NEC is not a design or instructional manual and is not intended to teach untrained people how to install electrical wiring.

Question 1: The purpose of the NEC is:

A: To teach electrical design.
B: To prevent fire hazards.
C: To prevent shock hazards.
D: The practical safeguarding of persons and property from hazards arising from the use of electricity.

Question 2: 90.2(A) Covered.

Question ID#: 10513.0

The NEC covers the installation of electrical systems in publicly owned buildings and structures. It also covers privately owned commercial buildings, industrial plants, and dwellings.

Outdoor installations such as carnivals, parking lot lights, and yards as well as temporary installations for construction sites and holiday decorative lighting are covered by the NEC. As seen in the illustration, floating buildings and docks are also covered.

Determining whether or not the NEC covers facilities owned by a utility company is more complicated. Buildings and structures used for generating electricity like power plants, hydroelectric dams, and substations are not covered by the NEC. However, the NEC covers offices, warehouses, garages, machine shops, and recreational buildings owned by utilities. Parking lot lighting owned and maintained by utilities is not covered by the NEC.

The NEC covers buildings on land and buildings that float.

Question 2: Which of the following electrical installations are covered by the National Electrical Code?

A: Wiring in floating buildings.
B: Branch circuits in a utility generating plant.
C: Luminaires on ships.
D: Machinery in underground mine installations.

Question 3: 90.2(B) Not Covered.

Question ID#: 10514.0

The NEC applies to garages but not trucks or cars.

A number of installations are not covered by the National Electrical Code. For example, installations in ships, aircraft, automobiles, rail cars, signal and communication facilities are not covered by the NEC. Even though floating buildings are covered, watercraft are not.

The installation of equipment under the exclusive control of communication utilities such as telephone and CATV, is not covered by the NEC. However, installation of signal and communication conductors and equipment in buildings and structures not owned by these utilities is covered. An example of equipment not covered by the NEC is a CATV booster used to boost the signal to CATV customers in rural areas.

Facilities of electric utilities used for generation, transmission or distribution of electricity are also exempt from the requirements of the NEC. For example, power plants used for generating electricity and utility substations are not covered. Utility installations in legally established easements or rights of way are not covered. Utility installations that are covered by written agreements with public service commissions, utility commissions or other regulatory agencies are also not covered by the NEC.

Question 3: Which of the following electrical installations is not covered by the National Electrical Code?

A: Commercial buildings less than 3 stories.
B: Utility switch yards.
C: Mobile homes.
D: Public swimming pools.

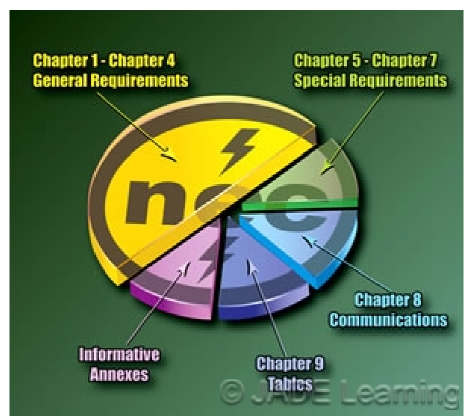
Question 4: 90.3 Code Arrangement.

Question ID#: 10515.0

The NEC includes an introduction and nine chapters. The introduction explains the purpose of the NEC, what it applies to, how it is enforced, and how it is organized. Chapters 1-4 apply to installations in general while chapters 5-7 apply to certain types of occupancies, equipment or conditions such as hazardous locations, hospitals, mobile homes, signs, swimming pools, emergency systems and low voltage wiring. Chapter 8 covers Communications Systems. Chapter 9 includes various tables and Informative Annexes A-I.

The requirements in chapters 5-7 modify or add to the material in chapter 1-4. For example, section 725.3 states "O***nly those sections of Article 300 referenced in this article shall apply to Class 1, Class 2, and Class 3 circuits".*** Because 300.17, 300.21 and 300.22 are the only sections of Article 300 that are mentioned in Article 725, those sections are the only ones that apply to Article 725.

Chapters 1-7 do not apply to chapter 8 unless specifically mentioned in Chapter 8. For example, Section 800.3(B) requires communications circuits installed in plenums to comply with section 300.22(A).



The NEC® is divided into 9 chapters that are outlined in section 90.3.

Question 4: How many chapters does the NEC have?

A: 4.
B: 6.
C: 8.
D: 9.

Definitions.

Question 5: 100 Accessible (Equipment) and (Wiring Methods).

Question ID#: 10517.0

The disconnect adjacent to HVAC equipment above a dropped ceiling is considered "accessible" even though access to it requires use of a ladder.

The term ***accessible*** when describing the requirements for access to equipment is defined in Article 100 as follows: ***Admitting close approach; not guarded by locked doors, elevation, or other effective means.***

For equipment to be accessible it must not be guarded by locked doors or by elevation above the floor or platform. However, if a key is made available to the personnel requiring access, then equipment behind a locked door is considered accessible.

The term ***accessible*** when describing the requirements for acces to wiring methods is defined in Article 100 as follows: ***Capable of being removed or exposed without damaging the building structure or finish or not permanently closed in by the structure or finish of the building.***

For wiring methods to be accessible they must be capable of being removed without damaging the building finish and cannot be closed in by the building structure. For example, a junction box covered with sheet rock is not considered to be accessible. However, a junction box located above a lay-in ceiling is considered to be accessible. Another example is a busway switch installed on a busway located in the ceiling of an industrial facility. The switch is considered accessible even if it is located more than 6 ft. 7 in. above the floor.

Question 5: Accessible (as applied to equipment) means admitting ________ approach.

A: Quick.
B: Close.
C: Guarded.
D: Unsupervised.

Question 6: 100 Accessible (Readily Accessible).

Question ID#: 10518.0

Readily accessible equipment must not be blocked by obstacles and must be capable of being reached quickly without the use of tools or ladders.

Overcurrent devices must be readily accessible so they can be reached in case of an emergency. Equipment that is mounted higher than 6 ft. 7 in. is not considered readily accessible because it cannot be reached while standing on the floor or platform.

Service equipment is required to be located in a readily accessible location. The service disconnecting means must be capable of being operated quickly to disconnect utility power from a building or structure. Equipment is still considered readily accessible if it is located in an electrical equipment room that is locked, as long as qualified persons have the key.

GFCI receptacle outlets must always be readily accessible.

Switchgear in a locked room is considered "readily accessible" provided those requiring ready access have a key.

Question 6: What does readily accessible mean?

A: Equipment can be reached using a portable ladder.
B: Equipment is not behind locked doors.
C: Wiring that is exposed and not covered by wall finish.
D: Capable of being reached quickly.

Question 7: 100 Branch Circuit.

Question ID#: 10519.0

Branch circuit conductors are installed between the final overcurrent device and the load supplied by the circuit.

A branch circuit consists of the circuit conductors between the final overcurrent device and the outlet the circuit supplies. The overcurrent device protecting a branch circuit is either a circuit breaker, as shown in the illustration, or a fuse. The outlet is equipment that utilizes electricity such as, luminaires, motors, or heaters. Whether this equipment is hard wired or cord and plug connected to a receptacle it is still considered a branch circuit.

A branch circuit can be dedicated to a single outlet or it may be a general purpose branch circuit supplying two or more lighting outlets or receptacles for appliances.

A common practice in industrial locations is to use 50 amp receptacles on branch circuits for certain types of equipment. This allows equipment to be quickly moved from one place to another.

Multiwire branch circuits are commonly used in commercial, institutional, and industrial locations. A multiwire branch circuit consists of a shared grounded (neutral) conductor and two or three ungrounded conductors, each protected by a fuse or circuit breaker. When single pole circuit breakers are used on a multiwire branch circuit, handle ties must be used to connect the handles together.

A multiwire branch circuit supplying two separate groups of fluorescent luminaires is considered to be two branch circuits.

Question 7: Which of the following installations is a branch circuit?

A: Conductors from a service disconnect to a panelboard.
B: Conductors that feed a motor control center.
C: Conductors that supply a load center.
D: Conductors between the final overcurrent device and a piece of industrial machinery.

Question 8: 100 Continuous Load.

Question ID#: 10520.0

A continuous load is a load that is on for 3 hours or more. Lighting in a commercial or industrial location is always considered a continuous load.

The wire size and overcurrent protection for continuous loads is calculated at 125% of the load. For example, the wire to feed a 100 amp lighting load in an office building must be selected to carry 125 amps. The overcurrent protection for the load must be set at 125 amps also.

The increased size of the wire and overcurrent protection for continuous loads is to allow for the heat buildup at the terminals of equipment. The amount of current in a circuit does not actually increase after 3 hours. But the heat at the equipment terminals does increase over time and a larger wire will be less likely to overheat, and a larger fuse or circuit breaker will not nuisance trip because of higher temperatures.

Lighting is considered a continuous load if it operates for 3 or more hours.

Question 8:   A continuous load is a load where the maximum current is expected to continue for ___ hours or more.

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

Question 9: 100 Feeder.

Question ID#: 10521.0

Feeders are the circuit conductors between service equipment and the final branch-circuit overcurrent device.

The definition of a feeder in Article 100 is "***All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device***." For example, the conductors that run from the load side of a 200 amp fusible disconnect to a 200 amp subpanel are considered to be feeder wires.

In the photo, the switchboard is being supplied by a feeder from the main distribution panel. It also would be possible to have a feeder from this switchboard feeding a panelboard located elsewhere in the building.

The difference between a feeder and a branch circuit is that a feeder usually runs from one overcurrent device to another overcurrent device and a branch circuit is installed from the final overcurrent device to the outlet(s).

Question 9:   Which of the following circuits is a feeder?

A: The conductors between the service equipment and the final branch circuit overcurrent device.
B: The conductors between the secondary of a utility transformer and an electric service cabinet.
C: The conductors from the service drop to the service equipment.
D: The conductors from the final overcurrent device to the equipment outlet.

Question 10: 100 Grounded. Grounding.

Question ID#: 10522.0

The term grounded is defined in Article 100 as ***"Connected (connecting) to ground or to a conductive body that extends the ground connection."***

Electrical systems are grounded by being connected to the earth through the grounding electrode system.

For conductors or equipment to be grounded they must be connected to earth. No building, structure or object can take the place of the earth. Equipment connected to building steel is grounded only if the building steel is itself connected to earth. The building steel does not take the place of earth, and the equipment would not be grounded if the building steel didn't extend the ground connection, by being physically in contact with earth.

Grounding requires non-current carrying metal parts to be connected to an equipment grounding conductor that is connected to a grounding electrode at the service. The grounding electrode is connected to earth. This connection puts all the metal parts of electrical equipment and raceways at basically the same electrical potential as earth, which is zero volts. So, even under fault conditions, there is practically no voltage difference between equipment that is properly grounded and the earth or anything that is in contact with the earth such as structural steel, concrete floors. metal water pipes or you!

In the photo the grounding electrode conductor is connected to a grounding electrode. The grounding electrode is a driven ground rod.

Question 10: According to the definition, which of the following connections is grounded?

A: Conduit made up wrenchtight.
B: An equipment grounding conductor run in the same conduit as the circuit conductors.
C: A bonding jumper used between a receptacle and a metal box.
D: A connection between a metal enclosure and the building steel that has structural metal members in direct contact with the earth for 10 ft or more.

Question 11: 100 Ground-Fault Protection of Equipment.

Question ID#: 10523.0

Ground-fault protection of equipment is required for solidly grounded wye connected electric service disconnects rated 1000 amperes or more if the voltage exceeds 150 volts to ground but does not exceed 600 volts phase-to-phase.

Ground fault protection of equipment is designed to protect equipment from damaging line-to-ground fault currents by causing the service disconnecting means to open all ungrounded conductors.

Systems designed to provide Ground Fault Protection of Equipment typically have a 30-mA trip level. These 30-mA protective systems are designed to protect equipment from damage due to overheating or fire and should not be confused with 5-mA ground-fault circuit interrupters (GFCIs), which are designed to provide personnel protection from electrical shock.

Solidly grounded wye electric services of 1000-amps or more rated at more than 150 volts to ground but not exceeding 600 volts phase-to-phase are required to have ground fault protection for equipment. For example, a 1000-amp, 277/480 volt service disconnect is required to have ground fault protection of equipment.

A ground fault on a large service can quickly develop into a phase-to-phase fault and cause massive damage to equipment and extreme danger to personnel. Ground fault protection for equipment will de-energize the service when the ground fault current reaches the trip point.

Question 11: Which of the following statements about ground fault protection of equipment is true?

A: The trip level for ground fault protection for personnel is set to 4-7 mA.
B: Ground fault protection for equipment is required on a 480/277 volt, 3-phase, Wye service disconnect rated 1000 amps.
C: Ground fault protection for equipment is required on a 480/277 volt, 3-phase, Wye service rated 800 amps.
D: Ground fault protection for equipment is designed to protect personnel from shock hazards.

Question 12: 100 In Sight From (Within Sight From, Within Sight).

Question ID#: 10524.0

The in sight from or within sight of requirement means a disconnect has to be visible and not more than 50-ft. from equipment it supplies.

The NEC uses the terms ***in sight from, within sight from, or within sight of*** to mean the same thing. These terms mean that the equipment must be visible and within fifty feet.

An equipment disconnect that is in sight from the equipment means the person working on the equipment can control the disconnect. A disconnect that is within sight of a machine means the electrician or operator of the equipment can see the machine before energizing it.

Within sight from means two things: (1)Not further than 50 ft. (2)There must be a clear line of sight between the two pieces of equipment.

If a disconnect is located 25 ft. away from a piece of equipment, but the disconnect is located around a corner, then the disconnect is not within sight of the equipment. If the equipment is clearly visible while standing at the disconnect, but the distance is greater than 50 ft. then they are not within sight from each other.

The disconnect in the photo is located next to the HVAC unit it supplies.
The disconnect is clearly visible and within 50 ft. of the HVAC unit, so the Code considers them to be within sight of each other.

Question 12: In which installation would the two types of equipment be considered within sight of each other?

A: An outdoor receptacle located 75 ft. away from an outside condenser unit.
B: Two disconnects mounted 6-feet above the finished floor on each side of a 6 ft. wide conveyor belt that is installed 2-feet above the finished floor.
C: A circuit breaker located in an inside panelboard that feeds a rooftop compressor.
D: A feeder circuit breaker located 100 ft. away from a clearly visible industrial machine that it supplies.

Question 13: 100 Qualified Person.

Question ID#: 10525.0

A "qualified person" has the knowledge and skill related to the installation, construction, and operation of electrical equipment and the safety training necessary to identify and avoid the hazards it presents.

A qualified person has the skills and knowledge required to perform the installation, construction and operation of electrical equipment and has received safety training in recognizing and avoiding possible hazards.

An individual may be a qualified person in one area and not qualified in another area. For example, a person could be qualified to work on equipment 600 volts and less, but not over 600 volts.

State licensing in the electrical trade does not make someone a qualified individual, and the number of years of practical experience is not part of the definition of a qualified person. A qualified person does have the skills and knowledge to install electrical equipment and no one can be considered qualified unless they have demonstrated a thorough knowledge of electrical construction practices.

Qualified persons are required to have safety training appropriate for the work they perform. The standard for safety training in the electrical trade is NFPA 70E, ***Standard for Electrical Safety in the Workplace***.

The goal of safety training is to be able to recognize a hazard and avoid the hazard.
The hazards most common in electrical work are shock, arc flash and arc blast. A qualified person avoids these hazards by de-energizing equipment before working on it. If working on live equipment is necessary, a qualified person protects himself with the proper level of Personal Protective Equipment.

Question 13: One who has skills and knowledge related to electrical installations and has received safety training on the hazards involved is known as a ________ person.

A: Qualified.
B: Smart.
C: Professional.
D: Trainable.

Question 14: 100 Separately Derived System.

Question ID#: 10526.0

Most Transformers are separately derived systems.

A separately derived system is defined in Article 100 as "***An electrical source, other than a service, having no direct connections(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections.***

Most transformers and some generators are considered separately derived systems. A generator that has a grounded (neutral) conductor bonded to the frame of the generator is a separately derived system. When used as standby power for a grounded electrical service, the generator transfer switch is required to switch the neutral.

Another example of a separately derived system is the typical transformer with a 480 volt primary and a 120/208 volt secondary. The neutral secondary conductor is derived from the transformer and there is no direct connection to the transformer primary conductors.

With each of these separately derived systems, bonding and grounding is required on the secondary side of the transformer. Grounding at a transformer is similar to grounding at the service; the grounded conductor is connected to a grounding electrode conductor.

Grounding and bonding conductors of a separately derived system are permitted to be connected to grounding and bonding conductors of other sources such as the service grounding electrode system.

Question 14: Which of the following statements about the circuit conductors (other than established by grounding/bonding connections) of separately derived systems is correct?

A: The grounded conductor of the separately derived system is directly connected to the grounded conductor of the source system.
B: Circuit conductors of a separately derived system are directly connected to the source system at the service.
C: There is no direct electrical connection between the circuit conductors of the separately derived system and another power source system other than those established by grounding/bonding connections.
D: Separately derived systems are not connected to a grounding electrode system.

Requirements for Electrical Installations.

Question 15:   110.3(A) Examination, Identification, Installation, and Use of Equipment.

Question ID#: 10528.0

Equipment is required to be marked indicating its suitability for use.

Equipment is designed for a specific purpose and it must be installed for that purpose. Panelboards are designed to house circuit breakers and not designed to be used as junction boxes, unless adequate space is provided. Indoor enclosures are designed for dry locations and cannot be used outdoors, exposed to the weather. Disconnects used as service equipment must be suitable for use as service equipment. Luminaires used inside a paint booth where combustible liquid issprayed must be designed and listed for a Class I Division I Classified location.

Equipment must be installed to meet the purpose and intended design of the manufacturer. Equipment is classified by type, size, voltage, current capacity and specific use. The suitability of a piece of equipment for a particular application is shown by listing or labeling of the equipment by a third party testing agency, like Underwriters Laboratories.

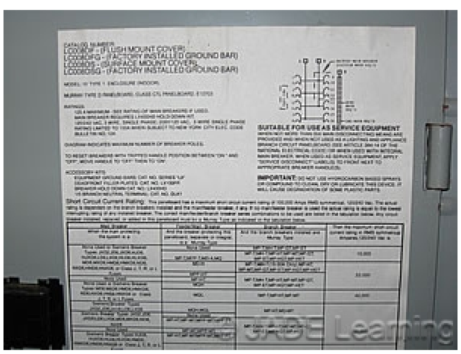
When a testing agency examines equipment they look for qualities such as strength and durability, wire-bending and connection space, electrical insulation, and heating effects under normal and abnormal conditions. They also check enclosures for electrical equipment to be sure there are not exposed parts that can be touched or reached by someone using the equipment.

Question 15:   When a third party testing agency examines electrical equipment, which of the following is not included in the examination?

A: The date of manufacture.
B: Voltage rating.
C: Current capacity.
D: Arcing effects.

Question 16:   110.3(B) Installation and Use.

Question ID#: 10529.0



Equipment shall be installed and used in accordance with its listing & labeling.

Installing equipment according to the NECÂ® means installing it in accordance with the manufacturer's listing and labeling. When manufacturers submit their equipment for evaluation and listing, the equipment is submitted with specific requirements for installation. These installation instructions then become part of the listing; and the NECÂ® requires the equipment to be installed per the instructions.

Inspection departments require listing and labeling because inspectors do not have the standards, tools, time, or expertise to examine equipment in the detail required to make a thorough evaluation. Listing and labeling is therefore necessary to assure equipment is safe for its intended use.

Sometimes, the manufacturer's instructions for listed equipment exceed the minimum requirements of the NECÂ®. For example, if the nameplate of an HVAC unit specifies a minimum circuit ampacity of 40 amps and calls for a minimum circuit conductor size of No. 6 AWG copper, then a No. 6 copper conductor is required to meet Code. Because No. 6 copper is part of the listing it is the smallest conductor that is permitted to be used.

Question 16:   Which of the following statements about equipment installation instructions is true?

A: Real men don't need to read the instructions.
B: The installation instructions are part of the equipment listing.
C: If equipment is installed according to the National Electrical Code it will be approved.
D: The installation instructions should be discarded with the packaging material.

Question 17: 110.9 Interrupting Rating.

Question ID#: 10530.0

The interrupting rating of a device cannot be less than the available fault current.

Circuit breakers are rated according to their trip setting. They are also classified according to their interrupting rating at the voltage available at the line terminals of the equipment.

The interrupting rating of a device is the amount of current it can take without blowing up. Most branch circuit type breakers have an interrupting rating of 10,000 amps. This means the circuit breaker can withstand that much fault current without causing an explosion.

If a 20 amp circuit breaker took a 10,000 amp fault it probably could not be put back in service. But the interrupting rating does not mean the device has to ever work again. It just means the breaker cannot explode and create a hazard to anyone in the area.

Whenever overcurrent devices are exposed to current levels above their interrupting rating the arc flash and arc blast pose a serious threat to electrical workers. It is very important that the interrupting rating of overcurrent devices is not less than the available short circuit current in order to protect equipment and personnel.

If the utility company installs larger capacity transformers, or if a distribution system is expanded and enlarged, it is possible the short circuit current available at the terminals of fuses and circuit breakers is greater than the interrupting rating of those devices. This can be a very dangerous situation and is a clear Code violation.

Question 17: The available short circuit current at the terminals of a 100-A circuit breaker is 15,000 amps. What is the minimum value required for the interrupting rating of the breaker?

A: Sufficient only to open the circuit if current exceeds the breakers amperage rating by more than 250%.
B: 100 amps.
C: Sufficient to open the circuit breaker under fault conditions with no regard to the actual available short circuit current.
D: 15,000 amps.

Question 18: 110.14(C) Electrical Connections - Temperature Limitations.

Question ID#: 10531.0

The terminal temperature rating of the equipment is used to select the conductor ampacity.

Circuit breakers and fuseholders have terminals to attach wires to the circuit breaker or fuseholder. The overcurrent device is the beginning of the branch circuit or feeder and there must be a terminal to connect the conductor. In fact, a circuit breaker is an assembly which includes the tripping mechanisms and the means to attach a conductor. A fuseholder is also an assembly which is made to hold a fuse of a certain voltage and current rating and the means to connect a conductor. If the terminal gets overheated it can adversely affect the operation of the fuse or circuit breaker.

To prevent overheating at the terminals, Section 110.14(C) requires the rating of the wire to be equal to or greater than the rating of the terminal. The UL marking guide for Molded Case Circuit Breakers explains: ***All circuit breakers rated 125A or less are marked for use with 60 degree C, 60/75 degree C, or 75 degree C only wire. This marking indicates the proper wire size for termination in accordance with Table 310.15(B)(16) of the NEC. It is acceptable to use wire with a higher insulation rating if the ampacity is based on the wire temperature rating marked on the breaker.***

Most terminals today are marked 60/75 degree C or 75 degree C. This means that whatever the ampere rating of the overcurrent device, the 75 degree C rating of the wire, taken from Table 310.15(B)(16), can be used to select the conductor. If the terminal is marked for 60 degree C conductors, the ampacity of the conductor must be selected from the 60 degree column of Table 310.15(B)(16) even if the conductor is rated for 90 degrees.

In general, the 90 degree C ampacity ratings for conductors is only used in derating for ambient temperature and when there are more than 3 current carrying conductors in conduit. The 90 degree C ampacity ratings of conductors cannot be used because in wiring for 1000 volts and below there are no overcurrent devices with 90 degree C rated terminals.

Question 18: What is the minimum size THHN, 90 degree C conductor for a 100 amp circuit breaker with 75 degree C rated terminals?

A: No. 3 AWG cu.
B: No. 2 AWG cu.
C: No. 1 AWG cu.
D: 1/0 AWG cu.

Question 19: 110.16 Arc Flash Hazard Warning.

Question ID#: 10532.0

Labels applied to the outside of electrical equipment provide an arc flash hazard warning.

Many commercial and industrial types of equipment require arc flash hazard warning labels, including:

- Switchboards
- Switchgear
- Panelboards
- Industrial control panels
- Meter socket enclosures
- Motor control centers

Arc Flash hazard warnings are not required for equipment installed in dwelling units. Arc Flash hazard warnings in commercial locations must (1) Use standardized colors and language. (2) Be permanently attached to the equipment and cannot be handwritten. (3) The label must be suitable for the environment involved. (110.21)

An arc flash can cause serious damage to equipment and injury to personnel. The explosion from electrical faults rapidly vaporizes the conductors and metals involved in the fault and melted metal is blown with extreme force in all directions by the explosion.

Individuals injured in arc flash accidents are often severely burned or killed. Only personnel who have completed training in safe work practices, as outlined in NFPA 70E, are qualified to work on equipment marked with an arc flash hazard warning label. NFPA 70E training covers safe work practices and the selection of various types of Personal Protective Equipment (PPE) required when working on or near energized equipment.

Question 19: Which types of electrical equipment do not require an arc flash warning label?

A: A fusible disconnect installed in a factory.
B: A transfer switch installed in a grocery store.
C: A panelboard installed in a dwelling unit
D: A combination motor starter installed in a college classroom building.

Question 20: 110.18 Arcing Parts.

Question ID#: 10533.0

Enclosures contain arcs from electrical equipment and prevent persons from contacting energized parts.

The NEC states that, "***Parts of electrical equipment that in ordinary operation produce arcs, sparks, flames, or molten metal shall be enclosed or separated and isolated from all combustible material***."

Fuses and circuit breakers must be installed in enclosures so that under fault conditions if an arc occurs it will not cause injury to anyone in the vicinity. Luminaires installed over Class I Division II hazardous (classified) locations are required to be of the totally enclosed type to prevent sparks from reaching flammable material or gases. Motors that arc while in operation must be enclosed to protect adjacent material from catching fire. Switches can produce an arc and must be installed in an enclosure to guard the live parts and shield personnel and other equipment from the danger of arcing parts.

Question 20: Parts of electric equipment that in ordinary operation produce arcs shall be enclosed or separated and isolated from ________ material.

A: Insulated.
B: Grounded.
C: Combustible.
D: Conductive.

Question 21: 110.22 Identification of Disconnecting Means.

Question ID#: 10534.0

The labels on these disconnects clearly indicate their purpose.

Each disconnecting means shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident. What is evident is a judgment call.

For example, in some jurisdictions the location is accepted as evidence of purpose when a disconnect is mounted adjacent to a water-heater or mounted on the side of rooftop HVAC equipment. However, what is evident to an installer may not be evident to an operator.

The requirement for the identification of disconnecting means to be durable does not necessarily require an engraved plastic nameplate. However, the labeling must be done according to 110.21 that requires using standardized colors and words or symbols. The identification label must also be attached to the equipment and cannot be hand written. And the label must be suitable for the environment, so if the equipment is outdoors, the labels must be weatherproof.

Self-adhesive marking labels similar to those used in this illustration are commonly available and comply with Code requirements.

The labels in this illustration comply with the requirements of 110.22(A) by clearly identifying each load by both function and by horse power. However, if there was more than one 480-V, 100 HP Compressor or more than one 100 HP Dryer these labels would not be specific enough to clearly identify the loads supplied by the disconnects.

Question 21: Each disconnecting means shall be marked to indicate its ________.

A: Installation date.
B: Location on the property.
C: Type.
D: Purpose.

Question 22: 110.24 Available Fault Current.

Question ID#: 10535.0

The available fault current must be marked on service equipment at non-dwelling unit locations.

This section requires the maximum available fault current to be field marked on service equipment, except at dwelling units. The field marking must be legible and able to withstand the environment where the service equipment is located. The field marking must include the date when the fault current calculation was performed.

When the service equipment is modified, or when changes are made that might change the maximum available fault current, the fault current calculation must be recalculated and the equipment marked with the new values and the date when the most recent calculation was done.

The maximum available fault current at a service can also be affected by changes made by the utility company. For example, available fault current is usually affected anytime the utility company changes a transformer supplying a facility. However, changes made by a utility remote from a facility such as relocating a substation to change the length of the primary supplying a facility can also affect the available fault current for all of the facilities supplied by the substation. The only way to ensure that changes made by a utility do not affect a facility is to maintain communication between the facility engineering staff and the utility, and to have engineering calculations done at the facility to determine maximum available fault current when changes are made on either side of the service point.

An exception allows industrial installations with qualified personnel to skip the field marking requirement.

The available fault current at the terminals of the utility delivery point should be readily available from the utility. Marking it on the equipment with the date will make it easier to confirm the interrupting rating of the equipment is within the range of the available fault current and how long ago the calculation was made.

An Informational Note clarifies that the available fault current is to be used for determining the required short-circuit current ratings of equipment. It is not to be used to establish hazard risk boundries or the necessary PPE required by qualified persons when working on energized equipment. ***NFPA 70E, Standard for Electrical Safety in the Workplace***, should be used for personnel safety issues when equipment must be serviced while energized.

Question 22: Which of the following is an acceptable label to be posted on the service equipment showing the available fault current?

A: Maximum available fault current 98,600 amperes.
B: Maximum interrupting rating 17,210 amperes.
C: Maximum available fault current 42,517 amperes. August 14, 2012.
D: Maximum short circuit rating 11,280 amperes. August 8, 2012.

Question 23: 110.26(A)(1)(2)(3) Depth, Width and Height of Working Space.

Question ID#: 10536.0

Working space has 3 dimensions. Depth, Width, and Height.

The required minimum depth of the working space in table 110.26(A)(1) varies with voltage and in relation to grounded or energized components on the opposite side of the working space. The table describes the arrangements of 3 typical installations as conditions 1, 2, or 3.

Where the voltage is equal to or less than 150 volts, 3 ft. is the minimum required working depth for all 3 conditions. But, at higher voltages, the depth varies for each condition. For example, if a worker is exposed to energized parts while testing or servicing 480 volt switchgear and there are no energized or grounded parts on the opposite side of the working space, then it is a condition-1 situation; and, the minimum required depth of the working space is 3-ft.

However, if the worker is exposed to bare energized parts on one side of the work space and grounded parts on the other side of the work space, such as a concrete or block wall, it is a condition-2 situation; and, the minimum required depth is 3 ft. 6 in. Brick, tile, or concrete walls are considered to be grounded. But, if the worker is exposed to bare energized parts on both sides of the work space it is a condition-3 situation; and, the minimum required depth is 4 ft.

Regardless of the depth of the work space, the width of the work space is required to be at least 30 in. or the width of the equipment, whichever is greater.

The minimum height (headroom) is required to extend from the floor up to a height of 6 1/2-ft. or the height of the equipment itself, whichever is greater. There are two exceptions: (1) In existing dwelling units, service equipment or panelboards that do not exceed 200 amperes. (2) Meters that are installed in meter sockets shall be permitted to extend beyond the other equipment.

The minimum working space requirements in Table 110.26(A)(1) are NOT required for the back and sides of equipment like dead-front switchboards, switchgear, or motor control centers where connections and renewable or adjustable components are not accessible from the back or sides of the equipment.

Question 23: What is the required work space depth in front of a 480 volt fusible disconnect where the wall opposite the disconnect is concrete block?

A: 30 inches.
B: 3 ft.
C: 3 ft. 6 in.
D: 4 ft.

Question 24: 110.26(C)(1)&(2) Large Equipment.

Question ID#: 10537.0

Equipment over 6 ft. wide and rated 1200 amps or more is considered to be large equipment, and has special working space requirements.

Section 110.26(C)(2) defines Large Equipment as:

Equipment rated 1200 amps or more and over 6 ft. wide.

The entrance and egress requirements for large equipment are strict because of the hazards workers face in the event of arc-flash accidents. Having ready access to an unobstructed means of egress (or way out) can be a matter of life or death in the event of catastrophic arc-flash incidents.

The switchgear in this illustration is Large Equipment in terms of both amperage and physical size. It is required to have a means of entrance and egress at each end of the working space unless one of two conditions is met:

- the means of egress is unobstructed ***or***
- the depth of the working space is twice that required in Table 110.26(A)(1).

Although only one exit is visible in this illustration, another exit door also equipped with a panic bar is behind the camera. A single exit door would be permitted if the work space in front of the switchgear is doubled.

Question 24: Which piece of equipment listed below is classified as large equipment?

A: 4 ft. and 1200 amps.
B: 8 ft. and 800 amps.
C: 5 ft. and 2000 amps.
D: 7 ft. and 1600 amps.

Question 25: 110.26(A & D) Height of Working Space and Illumination.

Question ID#: 10538.0

Working space is required to be illuminated and to have a minimum height of 6.5 ft.

Illumination of working space is required by 110.26(D). However, a separate lighting outlet is not required if the working space is illuminated by adjacent lighting. Lighting cannot be controlled by automatic means only, such as an occupancy sensor that does not have a manual override switch.

For example, if the electrical equipment were installed in a room where the work space were illuminated by general lighting in the room then no additional light is required. Regardless of the source of illumination, it is not permitted to be controlled only by automatic means such as an occupancy sensor. In this illustration illumination for the equipment is provided by an overhead fluorescent luminaire.

The minimum height of the working space in front of the equipment is 61/2 feet or the height of the equipment, whichever is larger. In this illustration the height of the workspace exceeds the minimum requirement of 6 1/2-feet. It is always acceptable to exceed the minimum requirements for work space height. Specifications for workspace height are now in section 110.26(A).

This illustration shows a large portable fan stored in the equipment room; but the fan is not within the required working space. The rubber mat in front of the 2 large disconnects provides workers standing in front of the equipment with some insulation from the cement floor and also reminds workers to keep the working space clear of obstructions at all times. Many facilities now outline the working space on the floor with paint or safety tape.

Question 25: What is the minimum height requirement at a 2000 ampere, 480 volt motor control center that is 8 ft. tall?

A: 6 feet.
B: 7 feet.
C: 61/2 feet.
D: 8 feet.

Question 26: 110.26(E) Dedicated Equipment Space.

Question ID#: 10539.0

The insulated pipes in the photo are considered as foreign systems and are not permitted in the dedicated space above the switchgear.

Dedicated equipment space is a three dimensional space reserved for electrical equipment and dedicated to the installation. Both indoor and outdoor equipment requires dedicated equipment space. The length and width of the space is outlined by the footprint of the equipment at floor level or grade.

Dedicated space extends from the floor to a height of 6 ft. above the equipment or the structural ceiling, whichever is lower. This space is set aside for conduit, cable tray, and other wiring methods to enter the equipment. No HVAC piping or ductwork, plumbing, or other foreign systems or equipment are permitted to be in or pass through the dedicated space.

If foreign systems or piping are installed immediately above the dedicated space, these systems must include protective equipment to prevent any leaks or drips from entering the dedicated space.

For example, if the footprint of a 7 ft. high MCC was 2 ft. x 6 ft. and the MCC was installed in a room with a 12 ft. ceiling. The dedicated equipment space would extend from the top of the MCC, 5 feet to the structuralc ceiling. Only electrical equipment associated with the MCC could be installed above the MCC. However, if the MCC was installed in a high-bay location with 35 ft. ceilings, foreign equipment and piping could be installed directly over the MCC provided it was at least 6 ft. above the top and included protective equipment to prevent drips or leaks from entering the dedicated space.

In this illustration a drip pan is not required because the piping is routed around the dedicated space.

Question 26: Which statement best describes dedicated equipment space?

A: The area in back of electrical equipment that is reserved for servicing the equipment.
B: The area that extends upward 4 feet from the top of the equipment.
C: A reserved space above electrical equipment where equipment from other systems is not permitted.
D: The area that extends from the top of the equipment up to 15 ft. above the equipment.

Question 27: Table 110.28 Enclosure Selection.

Question ID#: 10540.0

Match the outdoor or indoor Type of Enclosure to the conditions where the equipment will be located

Enclosures for electrical equipment not over 600 volts, and not in hazardous locations are selected from Table 110.28. Equipment such as panelboards, switchboards, motor control centers, transfer switches, enclosed switches, and general-purpose transformers are some of the types of equipment whose enclosures can be selected from Table 110.28

The Table is divided into types of enclosures for outdoor use and indoor use. None of the enclosures in the Table are intended to protect against condensation, icing, corrosion, or contamination that may occur within the enclosure or enter via the conduit or unsealed openings.

Enlosure types are identified with numbers and letters, for example 3R, 3S, 4X and 6P.

Outdoor enclosures are intended to protect against such conditions as rain, snow, sleet, windblown dust, temporary submersion or even prolonged submersion.

Indoor enclosures are intended to protect against such conditions as falling liquids and light splashing, circulating dust, lint, fibers, and flyings, or oil and coolant seepage.

To select the right enclosure for the conditions where the equipment is located, find the X in the Table that matches the conditions. For example, a Type 3R outdoor enclosure will protect against rain, snow and sleet, but not against windblown dust. A Type 2 indoor enclosure will protect against falling dirt and falling liquids and light splashing, but not hosedown and splashing water.

Question 27: Which Type of outdoor enclosure will protect electrical equipment from corrosive agents?

A: 3R.
B: 3S.
C: 4X.
D: 4.

Question 28: 110.33 Over 600 Volts. Entrance and Access to Work Space.

Question ID#: 10541.0

Personnel doors within less than 25 ft. of working space are required to have panic hardware.

For rooms, vaults, or other areas where equipment rated over 600 volts is installed, the doors into the area must be at least 24 in. wide and 6 1/2 ft. high.

For Large Equipment (equipment more than 6 ft. wide), an entrance is required at each end of the space unless means of egress (the exit path) is unobstructed or the depth of the working space is doubled as permitted in 110.33(A)(1)(a)&(b).

Personnel doors intended for entry into and exit from the working space that are less than 25 ft. from the work space are required to open in the direction of egress (the way out) and to be equipped with listed panic hardware that opens under pressure.

For example, the personnel door in this illustration is less than 25 ft. from the switchgear work space; it opens in the direction of egress and is equipped with a panic bar rather than a knob. Listed panic hardware is of critical importance to personnel who may be blinded or have severely burned hands resulting from an arc-flash incident.

Question 28: Two doors lead into a room where equipment rated over 600 volts is installed. One door is 18 ft. from the work space, the other door is 30 ft. from the work space. Which of the following statements is true?

A: Both doors require panic hardware.
B: Both doors must be at least 36 in. wide.
C: The door that is 30 ft. from the work space must have panic hardware.
D: The door that is 18 ft. from the work space must have panic hardware.

Question 29: 110.34(A) Over 600 Volts. Working Space.

Question ID#: 10542.0

Large equipment requires doubling the depth of working space or an exit at each end of the equipment.

The minimum depth of clear working space in front of equipment rated over 600 volts is required when the equipment may be serviced, maintained or tested while energized. The depth of the working space specified in Table 110.34(A) varies with the voltage and the whether or not grounded or energized components are on the side opposite the working space. The table describes the variables as conditions, 1, 2, and 3.

For example, on equipment where the voltage to ground is 2300-V, if there are no energized or grounded components on the opposite side of the working space it is a Condition 1 location. The minimum depth of the working space is 3 ft.

However, if the side opposite the energized components was grounded it becomes a Condition 2 location. The minimum depth of the working space is 4 ft. Note: the NEC considers brick, tile and concrete walls to be grounded.

And, if both sides of the working space contain bare energized parts, it becomes a Condition-3 location; and the minimum depth of the working space is 5 ft..

If the voltage to ground for the equipment is rated between 2501 volts and 9000 volts the minimum depth of the working space is 4 ft. for condition 1; 5 ft. for condition 2; and 6 ft. for condition 3.

The voltages in table 110.34 are voltages to ground. Voltage to ground of a 3-phase system is found by dividing the phase to phase voltage by 1.7333, which is the square root of 3. For example the voltage to ground of a 4160-V, 3-phase system is 4160 Ã· 1.7333 = 2400-V.

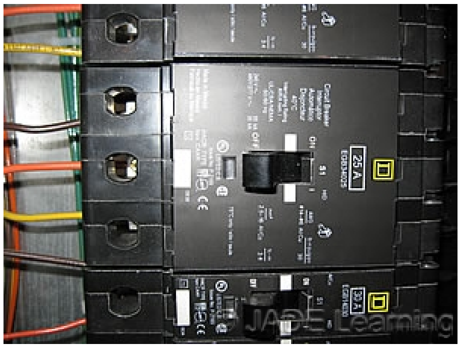
Question 29: According to Table 110.34(A), when there are exposed live parts on both sides of the working space, what is the minimum depth of clear working space in front of a grounded, 3-phase switchboard if the voltage to ground is 2400-V?

A: 3 ft.
B: 4 ft.
C: 5 ft.
D: 6 ft.

Branch Circuits.

Question 30: 210.3 Rating.

Question ID#: 10544.0



The rating of the overcurrent protective device determines the branch circuit rating.

The rating of a branch circuit is based on the maximum permitted rating of the fuse or circuit breaker. Branch circuits with multiple outlets are rated 15, 20, 30, 40, and 50 amps.

However, when branch circuits are very long, conductor size is often increased to prevent voltage drop. In these cases, the rating of the branch circuit is based on the actual OCPD used rather than on the maximum OCPD permitted for the larger conductor.

For example, if a 120 volt, single-phase, 30 amp circuit was needed to supply a load located 70 ft. from a panelboard, a No. 10 AWG copper conductor could be used and the branch circuit would be rated at 30 amps.

But, if the same load were 200 ft. from the panelboard a No. 6 AWG copper conductor would be required to maintain a 3% voltage drop. If a 30 amp OCPD was used to protect the No. 6 AWG conductor, the circuit's rating is still 30 amps.

Question 30: What determines the rating of a branch circuit?

A: The load.
B: The wire size.
C: The rating of the overcurrent protective device.
D: The voltage drop.

Question 31: 210.8 Ground-Fault Circuit-Interrupter Protection for Personnel.

Question ID#: 10545.0

GFCI protection is required for 125 volt, 15 and 20 amp receptacles to service HVAC equipment on rooftops of non-dwelling occupancies

The GFCI (Ground Fault Circuit Interrupter) protection for personnel required for single-phase 15 & 20 amp, 125 volt receptacles is provided by Class A GFCIs designed to trip when the current to ground is 6 mA or higher. They are available as circuit breakers and receptacles. GFCI protection shall be installed in a readily accessible location.

The requirements and exceptions for non-dwelling locations are listed in 210.8(B) which requires GFCI protection for 125 volt, single-phase, 15- and 20-ampere receptacles as follows:

- Bathrooms
- Kitchens (all kitchen receptacles, not just those serving countertops)
- Rooftops (Receptacles must be readily accessible from the rooftop only)
- Outdoors
- Sinks (where receptacles are installed within 6 ft. of the outside edge of the sink)
- Indoor wet locations

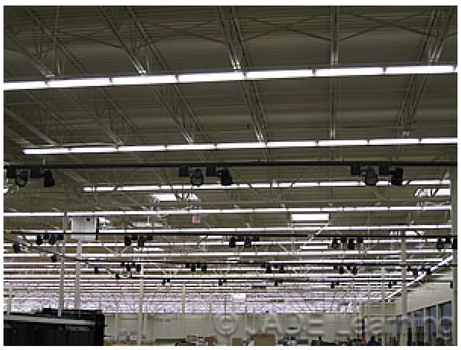
- Locker rooms with associated showering facilities
- Garages, service bays, and similar areas other than vehicle exhibition halls and showrooms

Question 31: Receptacles rated 125 volts, 15 and 20 amps, and located ________ shall be GFCI protected.

A: In a furniture showroom.
B: In a storage area without a sink.
C: Next to a bottled water dispenser.
D: On a strip-mall rooftop.

Question 32: 210.19 Conductors - Minimum Ampacity and Size.

Question ID#: 10546.0



The ampacity of branch circuit conductors is required to equal or exceed the load supplied.

The ampacity of branch circuit conductors is required to equal or exceed the maximum load supplied. When supplying a combination of non-continuous and continuous loads the minimum ampacity is required to be 125% of the continuous load plus 100% of the non-continuous load.

Continuous loads are loads that are on for 3 or more hours. Current flowing into a termination for 3 hours or more will cause increased heating of the Over-Current Protective Device (OCPD) terminals which may overheat the OCPD thermal trip mechanism, causing it to trip. By increasing the ampacity of the wires to 125% for continuous loads, the larger conductors act as "heat-sinks" drawing heat away from the terminals and minimizing problems caused by continuous loading.

For example, to calculate a 50 amp continuous load: 50 amps x 125% = 62.5 amps. Select a conductor that is rated at least 62.5 amps.

Grounded conductors are generally not connected to OCPDs, so overheating caused by continuous loads is not a problem; consequently, the ampacity of grounded conductors is permitted to be rated for 100% of continuous loads.

When a load is continuous, and there are more than 3 current-carrying conductors in conduit, or the ambient temperature is hotter than 86 degrees F, compare the size of the conductor needed for a continuous load (125%) with the size of the conductor needed to account for more than 3 current-carrying conductors or a hot ambient temperature and ***select the larger ofthe two***. In other words, don't triple derate.

For example, What is the minimum size 75 degree conductor required to supply a 50-amp continuous load with 7 current-carrying conductors in conduit (75Â°C terminals)?

Step 1: 50 amp continuous load =50 X 1.25 = 62.5 amps Table 310.15(B)16 indicates a No. 6 THWN CU conductor has an ampacity of 65 amps which is more than adequate to carry 62.5 amps.

Step 2: Table 310.15(B)(3)(a) indicates that for 7 current-carrying conductors the ampacity in Table 310.15(B)(16) is reduced to 70% of the table value; adjusted for 7 conductors the ampacity of the No. 6 is only 45.5 amps which is not adequate to carry the load.

Step 3: Apply adjustment factor to next larger conductor to see if it will carry the load. Table 310.15(B)16 indicates a No. 4 THWN CU conductor has an ampacity of 85 amps. Adjusted for 7 conductors the ampacity of the No. 4 is 59.5. amps which is adequate to carry the 50 amp load: 85 amps x .70 = 59.5amps.

Step 4: Select the No. 4 CU THWN which is the larger of the two conductors.

Question 32: What is the minimum ampacity for a 75 amp continuous load?

A: 75 amps.
B: 82.5 amps.
C: 93.75 amps.
D: 112.5 amps.

Question 33: 210.21 Outlet Devices.

Question ID#: 10547.0

Table 210.21(B)(2) describes the maximum load for cord and plug connected receptacles.

Outlet devices shall have an ampere rating that is not less than the load to be served.

Lampholders on circuits rated more than 20-A are required to be the heavy-duty type. This means that Medium-base screw-shell lampholders and fluorescent lampholders are prohibited on circuits rated at more than 20-A.

Receptacles: ***Single receptacles*** installed on individual branch circuits are required to have a rating equal to or greater than the circuit's rating. Single receptacles are defined in Article 100 as being "a single contact device" on a yoke. Duplex receptacles are not single contact devices.

Cord-and-Plug-Connected Loads supplied by a single receptacle connected to a circuit that supplies two or more receptacles or outlets are not permitted to exceed the loads specified in Table 210.21(B)(2) below:

Cord & Plug Connected Loads on Receptacles

Circuit Rated	***Receptacle Rated***	***Maximum Load***
15-A or 20-A	15-A	12-A
20-A	20-A	

16-A

30-A

30-A

24-A

Electric Range Receptacle ratings are based on single range demand loads specified in Table 220.55.

Question 33: When connected to a circuit supplying two or more receptacles or outlets, a 30A receptacle shall not supply a total cord-and-plug connected load in excess of_________amps?

A: 24 amps
B: 30 amps
C: 20 amps
D: 25 amps

Question 34: 210.63 Heating, Air-Conditioning, and Refrigeration Equipment Outlet.

Question ID#: 10548.0

Install receptacle for service within 25-ft. of HVAC equipment.

The single-phase, 15 or 20-A, 125-V receptacle required by this section is intended to be used to service HVAC & refrigeration equipment. It is required to be accessible, within 25 ft. of the equipment, and located on the same level as the equipment. If the equipment is at grade level, the receptacle must be installed at that level; however, if it is a rooftop unit, the receptacle is required to be located on the rooftop within 25 ft. of the equipment.

Because the equipment may need to be disconnected from power when being serviced, the receptacle is not permitted to be connected to the load side of the disconnect for the equipment. The receptacle for servicing the HVAC equipment must be GFCI protected, per 210.8.

A GFCI protected outlet located within 25 ft. of the HVAC equipment will make it unnecessary for the servicing technician to use an extension cord that could be plugged into an outlet without GFCI protection.

Question 34: Which of the following installations of a 15- 20-amp, 125 Volt HVAC equipment outlet is a Code violation?

A: A receptacle outlet mounted within 25 ft. and on the same level as the HVAC equipment.
B: A receptacle outlet mounted at ground level for an HVAC rooftop unit.
C: A receptacle outlet located not more than 10 ft. from the equipment.
D: A receptacle outlet mounted on the HVAC unit and connected to the line side of the equipment disconnect.

Feeders.

Question 35: 215.2 Minimum Rating and Size.

Question ID#: 10550.0

Feeder ampacity is required to equal or exceed non-continuous loads plus 125% of continuous loads.

Feeder conductors must be large enough to carry 100% of the load. The load is calculated according to Article 220.

If the calculated load is continuous the conductor must be sized to carry 125% of the calculated load. If the conductors are in an ambient temperature greater than 86 degrees F, or if there are more than 3 current-carrying conductors in conduit, the size of the conductors must be increased.

If a load is continuous and there are more than 3 current-carrying conductors in conduit or the ambient temperature is above 86 degrees F, take the larger of either (1) the continuous load (125%) or (2) the combined adjustments for a hot ambient and more than 3 current-carrying conductors.` `

Example for continuous and non-continuous loads:
The calculated load on a feeder includes 50 amps of non-continuous load and 50 amps of continuous load. Solution: Add the non-continuous load at 100% and the continuous load at 125%. 50 amps + 62.5 amps [50 amps x 1.25] = 112.5 amps.

Example for continuous loads and other ampacity adjustment conditions:
What is the minimum size 75 degree, cu conductor to feed a 110 amp continuous load with 4 current-carrying conductor in conduit? Solution. First: Calculate the continuous load. 110 amps x 125% = ` ` 137.5 amps. Second: Calculate the load with 4 current-carrying conductors. 110 amps Ã· .8 = 137.5 amps. Since the result of both calculations is the same, select a conductor that can carry 137.5 amps. 1/0 cu.

There is an exception that permits feeder conductors supplying continuous loads that are connected to overcurrent devices which are listed for operation at 100% of their rating to be calculated at 100%, not 125%. Another exception permits grounded conductors to be sized at 100%, if they are not connected to overcurrent devices.

Question 35: What is the minimum ampacity of a feeder conductor that supplies a non-continuous load of 75 amps and a continuous load of 100 amps?

A: 200 amps.
B: 250 amps.
C: 175 amps.
D: 150 amps.

Question 36: 215.10 Ground-Fault Protection of Equipment.

Question ID#: 10551.0

Ground-fault protection for equipment is required for solidly grounded 480/277 volt feeder disconnects rated 1000 amps or more.

Ground-fault protection for equipment is required for feeder disconnects rated 1000 amps or more for systems that are a wye-connected, solidly grounded, and that exceed 150 volts to ground but do not exceed 600 volts phase-to-phase. For example, a 277/480 volt, system solidly connected to a grounding electrode is not required to have ground-fault protection for equipment unless it is rated 1000 amps or more.

Ground-Fault Protection of Equipment on large feeders prevents ground faults from becoming phase-to-phase faults and causing massive damage to electrical equipment.

Ground fault protection for feeders is required to be provided according to 230.95, ground fault protection for services.

Section 230.95 has the following requirements for ground-fault protection for service equipment:

* Settings: maximum permitted setting of the ground-fault protection is 1200-A; and the maximum time delay is 1-second for ground-faults of 3000-A or greater.

* Fuses: switch and fuse combinations are required to use fuses that have faster response time than the switch which may take up to one second or longer to open.

* Performance Testing: a written record of a performance test conducted when the equipment was initially installed is required to be available to the AHJ. Manufacturer's instructions generally require periodic performance testing throughout the life of the equipment.

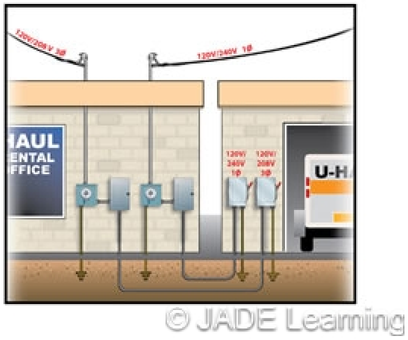
Question 36: Which of the following wye-connected feeders, rated 277/480 volts, is not required to have ground fault protection?

A: A feeder rated 800 amps.
B: A feeder rated 1000 amps.
C: A feeder rated 1200 amps.
D: A feeder rated 1600 amps.

Outside Branch Circuits and Feeders.

Question 37: 225.30 Number of Supplies.

Question ID#: 10553.0



In general, only one feeder is permitted to supply a building.

Section 225.30 permits only one feeder or branch circuit to supply a building or structure. This is similar to the requirement in 230.2 that permits only one service to supply a building or structure. Limiting the power sources makes it safer for maintenance or emergency personnel to remove all power from a building when necessary.

There are a number of conditions permitting additional branch circuits and feeders for the following:

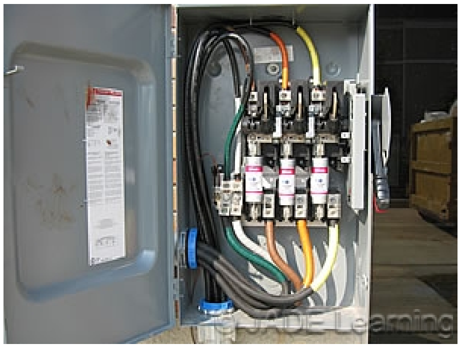
- ***Special Conditions:*** Multiple branch circuits or feeders are permitted for fire pumps, emergency systems, legally required and optional standby-systems, paralleled power production systems, and installations designed for more than one source of supply for increased reliability.
- ***Special Occupancies***: Buildings with no space for supply equipment to be available to multiple occupants; and a building or structure so large that multiple services are necessary.
- ***Capacity Requirements:*** Feeders operated at 1000 volts or less are permitted to be supplied by multiple branch circuits or feeders when the capacity requirements are more than 2000 amps.
- ***Different System Characteristics:*** multiple feeders or branch circuits are permitted to supply different voltages, frequencies, or phases.
- ***Documented Switching Procedures:*** Multi-building installations under single management are permitted to be supplied by more than one branch circuit or feeder when switching procedures are documented to ensure safety during maintenance and emergency situations. For example, this is common with multi-building industrial facilities and on multi-building campuses.

Question 37: Considering only the Capacity Requirement, what is the minimum calculated load required for a building to be supplied by more than a single outside feeder?

A: More than 400 amps.
B: More than 800 amps.
C: More than 1000 amps.
D: More than 2000 amps.

Question 38: 225.31 Disconnecting Means.

Question ID#: 10554.0



Feeders that supply buildings or structures require a disconnecting means that disconnects all ungrounded conductors.

Part II of Article 225 is labeled, ***Buildings or Other Structures Supplied by a Feeder(s) or Branch Circuit(s)*** and deals with outside feeders and branch circuits supplying more than one building or structure. Unless an installation is exempted by one of the 4 exceptions to the general requirement in, section 225.31, the NEC requires a means to disconnect all ungrounded conductors of a feeder or branch circuit that supplies or that passes through a structure or building.

For example a factory with a free standing structure such as a materials silo supplied by a 277/480 volt, 400 amp, 3-phase feeder from the switchgear in the factory requires a disconnecting means at the free standing silo.

Regardless of the voltage or amperage of the circuit, section 225.31 requires the disconnect at the freestanding building or structure to open all ungrounded conductors in the feeder or branch circuit.

Question 38: A 3-phase, 200 amp, outside feeder is fed from the Main Building and supplies a second building used for tool storage. Without application of any exception, which of the following statements is true?

A: If the feeder is protected at the Main Building, a second disconnect at the tool storage building is not required.
B: The grounded conductor is required to be disconnected at the tool storage building.
C: A disconnect at the second building is required to disconnect all ungrounded conductors from the building or structure supplied by the feeder.
D: A disconnect at the second building is required only if the feeder is 1000 amps or greater.

Question 39: 225.32 Location.

Question ID#: 10555.0

The disconnect for the supply is permitted either inside or outside the structure served.

The requirement in section 225.32 for the location of disconnects supplied by feeders or branch circuits is similar to the requirement in 230.70(A) for services. Both sections require the disconnect to be both readily accessible and to be located immediately inside or outside the building at the nearest point of entrance of the supply conductors.

In some cases, deciding what is the ***closest or nearest*** point that is readily accessible is a judgment call that should be discussed with the AHJ prior to installing the disconnect.

Four exceptions permit disconnects to be installed in an alternate location:

- Exception No.1 applies to facilities under one management with qualified personnel having documented safe switching procedures.
- Exception No.2 applies to ***integrated electrical systems*** in industrial locations in accordance with Article 685.
- Exception No.3 applies to poles and towers used as lighting stanchions.
- Exception No.4 applies to structures supporting signs in compliance with Article

600.

Question 39: An outside feeder supplies a building. The disconnecting means is required to be installed:

A: Close to the building served.
B: Either outside the building served or inside nearest the point of entrance of the conductors.
C: Inside the building served, nearest the point of entrance of the conductors.
D: Outside the building served.

Question 40: 225.60 Clearances over Roadways, Walkways, Rail, Water, and Open Land.

Question ID#: 10556.0

Minimum overhead clearance depends on location.

The minimum clearance of high voltage outside feeder conductors up to 22kV is listed in Table 225.60. The required clearance depends on the area the high voltage conductors pass over. Areas subject to pedestrian traffic do not require as much clearance as areas subject to vehicles. Areas that pass over railroad tracks require more clearance than walkways.

Table 225.60 Clearances over Roadways, Walkways, Rail, Water, and Open Land

Clearance

Location	M	Ft.
Open land subject to vehicles, cultivation, or grazing	5.6	18.5
Roadways, driveways, parking lots, and alleys	5.6	18.5
Walkways	4.1	13.5
Rails	8.1	26.5

Spaces and ways for pedestrians and restricted traffic

4.4

14.5

Water areas not suitable for boating

5.2

17.0

Question 40: What is the minimum clearance above a roadway for a high voltage feeder rated 12,460 volts?

A: 15 feet.
B: 16 feet.
C: 18 feet.
D: 18.5 feet.

Overcurrent Protection.

Question 41: 240.6 Standard Ampere Ratings.

Question ID#: 10558.0

Standard ratings for OCPDs are listed in Section 240.6.

Section 240.6 lists the standard ampere ratings for both inverse time circuit breakers and fuses as follows: 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000 amperes. Additional standard ampere ratings for fuses shall be 1, 3, 6, 10, and 601.

Under an overload condition current flow causes a buildup of heat within circuit conductors as well as within circuit breakers themselves. Because higher currents generate heat more quickly, inverse time breakers trip faster at higher levels of current - ***the higher the current, the faster they trip***. Dual element time delay fuses are similar in that they also open faster at higher current levels.

Some manufacturers make circuit breakers and fuses in non-standard sizes. The Code does not require the selection of non-standard sizes even though selection of a non-standard OCPD may provide conductors with greater protection.

An adjustable trip circuit breaker having a means that restricts access to the adjustment to prevent tampering or readjustment by unqualified personnel is considered as having the rating of the "long time pickup setting" set by the adjustment. If the means of adjustment of an adjustable circuit breaker is not provided with a mechanism to prevent tampering, its rating is considered to be its maximum setting.

Question 41: Which circuit breaker size listed below is not a standard size?

A: 25 amps.
B: 35 amps.
C: 45 amps.
D: 55 amps.

Question 42: 240.21(B) Feeder Taps.

Question ID#: 10559.0

Overcurrent Protection is required to be located at the point where conductors are supplied. Tap conductors are an exception to the rule.

A general statement in 240.21 says overcurrent protection must be provided in each ungrounded conductor at the point where the conductor receives its supply. Tap conductors are an exception to this rule in that they are conductors which have overcurrent protection that may be far greater than the value of the conductor.

A tap conductor cannot be tapped to supply another tap conductor (tap-a-tap). Also, the overcurrent device at the termination of the tap cannot be larger than the ampacity of the wire. In other words, the next higher standard size fuse cannot be selected.

The ampacity of a 10 ft. tap is required to be not less than 1/10th that of the rating of the Overcurrent Protective Device (OCPD) protecting the feeder supplying the tap conductor. For example, if a 10 ft. tap were supplied by a feeder protected with a 300 amp OCPD, the minimum ampacity of the tap conductor is 30 amps (1/10th of 300 amps = 30 amps).

If however, a tap that is longer than 10-feet but not more than 25 ft. in length is connected to a feeder, its ampacity is required to be not less than 1/3rd the rating of the OCPD protecting the feeder. For example, if a 20 ft. tap was connected to a feeder protected by a 300 amp OCPD, the tap conductor is required to have an ampacity of at least 100 amps.

Question 42: An 8 ft. tap is connected to a feeder which is protected at 200 amps. What is the minimum ampacity of the feeder tap?

A: 10 amps.
B: 20 amps.
C: 100 amps.
D: 200 amps.

Question 43: 240.24 Location in or on Premises.

Question ID#: 10560.0

The maximum height of a switch or circuit breaker operating handle is 6 feet, 7 inches.

Overcurrent Protective Devices (OCPDs) are required to be readily accessible so that they can be reached and operated quickly without moving obstructions or using portable ladders. The requirement specifies a maximum height of 6 feet, 7 inches for the center of the OCPD operating handle above the floor or working platform. Section 240.24 lists four situations where the overcurrent device is not required to be readily accessible.

For example, the maximum height requirement does not apply to the following:

- An OCPD and disconnect located on busway.
- An OCPD and disconnect supplying equipment adjacent to the disconnect that is located above a dropped ceiling or other area accessible by a portable ladder.
- An OCPD and supplementary disconnect within equipment such as fluorescent luminaries.
- An OCPD and disconnect for outside feeders and services that are guarded by locks accessible only to qualified personnel.

OCPDs are not permitted to be located in bathrooms of dwellings, guest rooms and suites of hotels and motels. OCPDs are also not permitted in clothes closets or other locations containing material that is easily ignitable.

Except for facilities such as hotels, dormitories, commercial buildings, and factories where electrical maintenance is provided by the building management, occupants are required to have ready access to OCPDs for areas they occupy or control.

Question 43: Which of the following installations meets the requirements for the location of overcurrent protective devices?

A: A panelboard with circuit breakers that is not accessible.
B: A fusible disconnect with the handle located 7 ft. above the working platform.
C: A fusible disconnect with the handle located 6 ft. 6 in. above the floor.
D: A panelboard with circuit breakers installed in the clothes closet of a guest room in a hotel.

Question 44: 240.101(A) Over 1000 Volts. Rating or Setting of Overcurrent Protection Devices.

Question ID#: 10561.0

The requirements for fuses and circuit breakers used on systems over 1000 volts are much different than the requirements for systems 1000 volts and less.

When the system voltage exceeds 1000 volts, the requirements for Overcurrent Protective Devices (OCPDs) are different than those for systems 1000 volts or less. For example, for systems 1000 volts or less, when the calculated value for an OCPD does not exceed 800 amps and it does not correspond with a standard size OCPD, the Code permits use of the next larger standard size OCPD. However, if the voltage exceeds 1000 volts, regardless of the location in the circuit, the maximum continuous current rating of a fuse can be up to three times the ampacity of the conductors. In the case of adjustable circuit breakers and fuses that are electronically actuated, the long-time trip element setting is not permitted to exceed six times the ampacity of the conductor.

A conductor used on a 480 volt system which is rated 230 amps can be protected at 250 amps, which is the next higher standard overcurrent device rating.

A conductor used on a 2300 volt system which is rated 100 amps can be protected by an overcurrent protective device with a rating not greater than 300 amps (3 times the rating of the conductor).

If a circuit breaker with an adjustable long time trip setting were used on the same 2300 volt system, its long time trip setting rating can be up to 6 times the ampacity of the 100 amp conductor, or 600 amps.

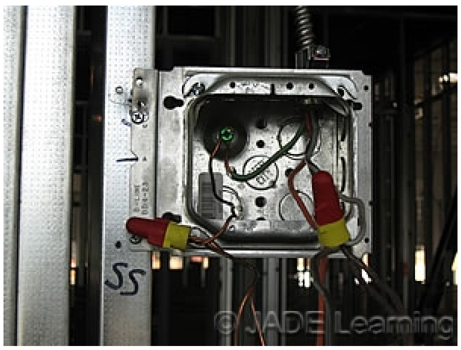
Question 44: What is the maximum rating of a fuse used on a 2300 volt circuit that protects a 50 amp conductor?

A: 50 amps.
B: 100 amps.
C: 150 amps.
D: 300 amps.

Grounding and Bonding.

Question 45: 100 Effective Ground-Fault Current Path.

Question ID#: 10563.0



Proper materials & techniques are required for an effective ground fault path.

When a ground-fault occurs and metal equipment is energized, the circuit must be de-energized as quickly as possible. If metal equipment remains energized, it is a deadly trap waiting for someone to come in contact with it.

The safest way to deal with a ground-fault is to trip the overcurrent device that supplies the faulted circuit.

In order to trip the circuit breaker, the ground-fault current path must be a low-impedance circuit. An effective ground fault current path must have lower impedance than any other available path that fault current might take such as building steel or water pipes. A low-impedance (AC resistance) path means the fault current will be high enough to trip the overcurrent device. If the fault-current path is not low-impedance, the fault-current will be too low to trip the circuit breaker, but high enough to kill a person.

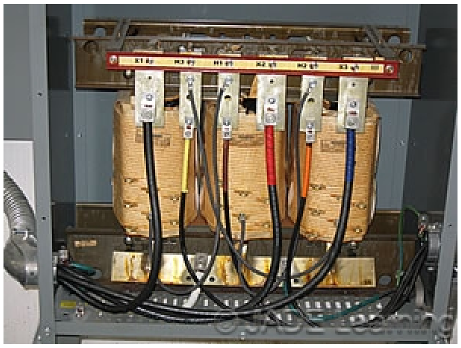
An effective ground-fault current path must be capable of carrying the maximum ground-fault current that it is likely to see. When equipment grounding conductors are sized according to Table 250.122 and grounding electrode conductors are sized according to Table 250.66, they are large enough to carry likely levels of fault current.

Question 45: Which of the following statements best describes an effective ground-fault current path?

A: A low impedance electrically conductive path.
B: A temporary path connected to earth.
C: A high resistance path from a ground-fault to the grounding electrode.
D: The grounded neutral conductor used to carry the unbalanced load.

Question 46: 250.30 Separately Derived Systems.

Question ID#: 10564.0



A transformer is the most common separately derived system.

Separately derived systems include solar photovoltaic systems, wind turbines, and fuel cells, but by far the most common separately derived systems are supplied by generators and transformers.

Just like services, separately derived systems are grounded at the source of the separately derived system, but not after the first disconnecting means. For both transformers and generators, the neutral on the secondary (derived) side of the separately derived system is connected to the grounding electrode, equipment grounding conductors, and the metal enclosure. A ***system bonding jumper*** connects the grounded conductor to the supply-side bonding jumper and the normally non-current-carrying metal enclosure. If the first disconnecting means and the source are in separate enclosures, a ***supply-side bonding jumper*** is installed with the circuit conductors from the source enclosure to the first disconnecting means.

250.30(A)(4) requires the grounding electrode to be as near as practicable to the location where the grounding electrode conductor is connected to the system. The grounding electrode conductor for a separately derived system is selected from Table 250.66.

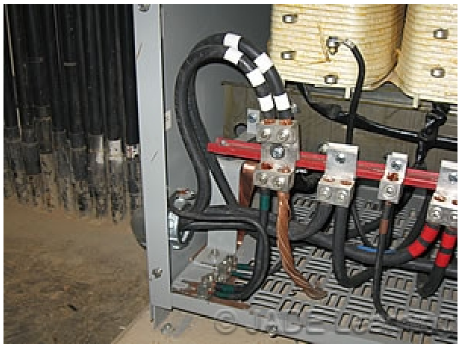
Informational Note No. 1 says that an on-site generator is not a separately derived system if the grounded conductor from the generator is solidly connected to the service-supplied grounded conductor. If the transfer switch for the generator does not switch the grounded conductor from the generator then the generator is not connected as a separately derived system.

Question 46: What is the minimum size copper grounding electrode conductor required for the connection to a structural steel electrode, when the secondary conductors are 4/0 copper?

A: No 6 AWG
B: No. 4 AWG
C: No. 2 AWG
D: 1/0 AWG

Question 47: 250.30 Grounding Separately Derived Alternating-Current Systems.

Question ID#: 10565.0



Transformers are permitted to be grounded at the transformer or at the first disconnect but NOT both.

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

The most common separately derived system is a transformer. The requirements for grounding separately derived systems are specified in section 250.30.

Transformers may be grounded either at the transformer or at the first disconnecting means, but not at both. However, most installations are bonded and grounded using a system bonding jumper to connect the grounding electrode conductor, the transformer's derived neutral conductor, and the equipment grounding conductor at the transformer rather than at the first disconnect.

A ***system bonding jumper*** is used to connect the grounded circuit conductor to the equipment grounding conductor of a separately derived system.

System bonding jumpers are permitted to be a bus, screw, or wire terminated by listed pressure connectors, listed clamps, exothermic welding, or other listed means. If the system bonding jumper is a wire its size is based on the size of the largest secondary phase conductor and is selected from Table 250.102(C)(1).

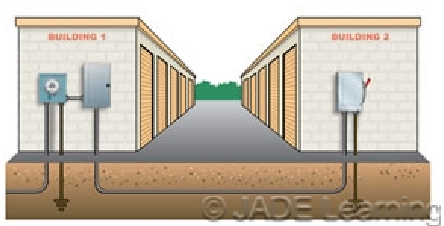
For example, using Table 250.102(C)(1), a transformer with 250 kcmil CU secondary phase conductors requires a No. 2 AWG CU system bonding jumper.

Question 47: The secondary phase conductors of a separately derived system are 500 kcmil CU. What is the minimum size copper system bonding jumper?

A: 6 AWG.
B: 4 AWG.
C: 1 AWG.
D: 1/0 AWG.

Question 48: 250.32 Buildings or Structures Supplied by Feeder(s) or Branch Circuit(s).

Question ID#: 10566.0



A feeder to a separate building must include an equipment grounding conductor. A grounding electrode system must be installed at the separate building.

Section 250.32 requires that a grounding electrode or grounding electrode system must be installed at separate structures or at a building supplied with a feeder from another building. An exception permits the grounding electrode to be omitted at a building or structure if it is supplied with a single branch circuit or a single multiwire branch circuit.

A feeder or branch circuit supplying a separate building or structure must include an Equipment Grounding Conductor (EGC) run with the supply conductors and the equipment grounding conductor is required to be connected to the disconnecting means and to the grounding electrode(s) at the separate building or structure.

The size of the Equipment Grounding Conductor is based on the size of the Overcurrent Protective Device protecting the feeder or branch circuit that supplies the structure and is sized from table 250.122.

For example, if a feeder is protected by a 40 amp fuse, the minimum size Equipment Grounding Conductor is a No.10 AWG CU or a No. 8 AWG AL conductor. If the OCPD is a 400 amp circuit breaker, the minimum size Equipment Grounding Conductor is a No. 3 CU or a No. 1 AL conductor.

Question 48: An equipment grounding conductor is run with the feeder conductors to serve an accessory building. The feeder circuit breaker is 70 amperes. What is the minimum size CU equipment grounding conductor?

A: 14 AWG.
B: 12 AWG.
C: 10 AWG.
D: 8 AWG.

Question 49: 250.50 Grounding Electrode System.

Question ID#: 10567.0

All grounding electrodes and metal water pipe are required to be bonded together to form the grounding electrode system.

All grounding electrodes present at a building must be bonded together to form a grounding electrode system. Individual grounding electrodes are tied together so they are no longer separate electrodes, but part of a grounding electrode system. A system of grounding electrodes has less resistance than a single electrode and provides a better ground.

Grounding electrodes include metal water pipe, the metal frame of a building, concrete-encased electrodes (such as rebar), ground ring, rod, pipe, and plate electrodes, and other local metal underground systems or structures.

Some state electrical boards have modified this section to say grounding electrodes are required to be bonded to other grounding electrodes if they are ***available,*** not if they are ***present***. For these jurisdictions, if a concrete-encased electrode is buried in the concrete and not available as a grounding electrode, it does not need to be included in the grounding electrode system.

Question 49: How is a grounding electrode system created at a building or structure?

A: By installing a driven ground rod.
B: By establishing a resistance to ground of less than 25 ohms.
C: By bonding together all grounding electrodes present at the building.
D: By bonding service equipment enclosures together.

Question 50: 250.52 Grounding Electrodes.

Question ID#: 10568.0

Structural metal that may become energized is required to be bonded to the grounding electrode system.

Section 250.52 lists the following eight different types of materials and structures permitted to be used as grounding electrodes:

- ***Metal Underground Water Pipe*** in direct contact with the earth for at least 10-feet. Except for industrial locations, the connection to the water pipe must be made within 5 ft. of where the pipe enters a structure.
- ***Metal Frame of the Buiding or Structure*** that is in direct contact with the earth for 10 ft. or more or that is encased in concrete in direct contact with the earth, or hold-down bolts securing the structural steel column that are connected to a concrete-encased electrode and is located in the support footing or foundation.
- ***Concrete-Encased Electrodes*** consisting of at least 20 ft. of either (1) bare or zinc galvanized or other electrically conductive coated steel reinforcing rods of not less than 1/2 inch or (2) bare copper conductor not smaller than 4 AWG encased in 2 inches of concrete in direct contact with earth, or within vertical foundations or structural components in direct contact with the earth.

Ground Rings that encircle the building or structure; the minimum length is 20 ft.; the minimum size is No. 2 AWG bare copper.

- ***Rod and Pipe Electrodes*** at least 8 ft. long. The minimum trade size of galvanized pipe or conduit is 3/4-inch. The minimum diameter of zinc coated steel rods is 5/8th of an in. and, the minimum diameter of listed stainless steel and copper rods is 1/2 in.

- ***Other Listed Electrodes*** permitted include Chemical Ground Electrodes such as the EritechÂ© system made by EricoÂ©.
- ***Plate Electrodes*** at least 2 ft. square; the minimum thickness of steel or iron electrodes is 1/4 in.; the minimum thickness for nonferrous electrodes is .06 in.
- ***Other Local Metal Underground Systems or Structures*** like underground piping systems, metal tanks, and well casings that are not bonded to a metal water pipe.

Question 50: What is the minimum length of a pipe or rod electrode?

A: 6 ft.
B: 8 ft.
C: 10 ft.
D: 12 ft.

Question 51: 250.64 Grounding Electrode Conductor Installation.

Question ID#: 10569.0

In general, grounding electrode conductors are required to be continuous.

Grounding electrode conductors must be securely fastened to the building or structure. A No. 4 AWG or larger grounding electrode conductor must be protected if it is exposed to physical damage. A No. 6 AWG grounding electrode conductor is not required to be protected if it is not exposed to physical damage. Section 250.64(B) allows grounding electrode conductors and grounding electrode bonding jumpers to be buried at any depth to protect them from physical damage. They are not required to be buried to the depths in Table 300.5.

Grounding electrode conductors must be installed in one continuous length without a splice, unless:

- The splice is made with an irreversible compression-type connector listed for grounding and bonding.
- The splice is made by exothermic welding.
- The grounding electrode conductor is made up of busbars which are connected together to form a single conductor.

On new installations there is no reason to splice the grounding electrode conductor. The permission to splice the grounding electrode conductor is most commonly used on old work or when electrical equipment is being replaced.

For buildings with multiple disconnecting means in separate enclosures the grounding electrode conductor can be installed in any one of three ways: (1) A common grounding electrode conductor can be installed based on the size of the largest service entrance conductor and taps can be connected to the common grounding electrode conductor based on the size of the ungrounded conductors in each disconnect. (2) Individual grounding electrode conductors can be installed from each disconnecting means to the grounding electrode system. (3) A grounding electrode conductor can be installed from a common location, such as a service wireway, directly to the grounding electrode system.

If the grounding electrode conductor is installed in a metallic raceway, the raceway must be bonded at both ends to the grounding electrode conductor so that the metallic raceway is electrically continuous from the point of attachment to the grounding electrode.

Question 51: Which of the following installations of a grounding electrode conductor is a violation?

A: Splicing the grounding electrode conductor with a split bolt connector.
B: Splicing the grounding electrode conductor by exothermic welding.
C: Splicing the grounding electrode conductor by using an irreversible crimp type fitting.
D: Splicing the grounding electrode conductor by connecting together two sections of busbars.

Question 52: 250.66 Size of Alternating-Current Grounding Electrode Conductor.

Question ID#: 10570.0

The size of the grounding electrode conductor is selected from Table 250.66 based on the size of the service-entrance conductors.

Table 250.66 is used to size the grounding electrode conductor for services and separately derived systems. It is based on the size of the largest ungrounded service-entrance conductor or the equivalent area for parallel conductors. The equivalent area for two, 500 kcmil conductors is 1000 kcmil.

The grounding electrode conductor will carry ground-fault current when there is a ground fault, but its purpose is not to be part of the ground-fault current return path back to the electrical source. The purpose of the grounding electrode and the grounding electrode conductor is to limit the voltage to ground if the building is hit by lightning and to provide a ground reference of zero volts for all the electrical conduit and enclosures.

Since the purpose of the grounding electrode conductor is not to carry fault-current, the largest grounding electrode conductor required by Table 250.66 is 3/0 AWG cu. If the equivalent size of the service-entrance conductors is more than 1100 kcmil the grounding electrode conductor is 3/0 AWG; if the equivalent size of the service-entrance conductors is 1500 kcmil, the grounding electrode conductor is 3/0 AWG; if the equivalent size of the service-entrance conductors is 2000 kcmil, 2500 kcmil, or 3000 kcmil, the grounding electrode conductor is still only required to be a 3/0 AWG cu.

Question 52: What is the minimum size copper grounding electrode conductor for a 1250 kcmil cu. ungrounded service-entrance conductor?

A: 1/0 AWG.
B: 2/0 AWG.
C: 3/0 AWG.
D: 4/0 AWG.

Question 53: 250.118 Types of Equipment Grounding Conductors.

Question ID#: 10571.0

Some types of metal raceways are permitted to serve as equipment grounding conductors.

The purpose of an Equipment Grounding Conductor is to provide a low impedance path to ground for fault current in order to facilitate the operation of overcurrent protective devices or the operation of ground fault detection systems in the event of a ground fault.

Section 250.118 lists fourteen different types of conductors permitted to be used as Equipment Grounding Conductors. The Equipment Grounding Conductors listed include the following types:

- Solid and stranded, bare and insulated copper and aluminum conductors.
- Flexible metal raceways: FMC, LFMC and FMT in lengths up to 6 feet
- Nonflexible metal raceways and tubing: RMC, IMC, EMT.
- Cable with protective metallic covering: AC, MC, & Mineral-Insulated Metal Clad cable. MC cable must provide an effective ground-fault current path.
- Cable Tray and Cablebus.
- Other listed metal raceways and listed auxiliary gutters.

- Surface metal raceway listed for grounding.

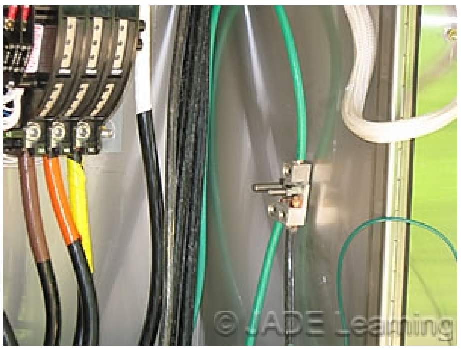
If the Equipment Grounding Conductor is a conductor or a raceway, it must be listed for the purpose and installed so that it provides a low impedance path to ground. Fault current travels on the Equipment Grounding Conductor from the point where the fault occurred all the way back to the service or transformer at a high enough value to trip the circuit breaker.

Question 53: Which of the following is not permitted to serve as an equipment grounding conductor?

A: 10 ft. of rigid metal conduit.
B: 20 ft. of electrical metallic tubing.
C: 6 ft. of surface metal raceway listed for grounding.
D: 10 ft. of flexible metal conduit.

Question 54: 250.122 Size of Equipment Grounding Conductors.

Question ID#: 10572.0



The size of the equipment grounding conductor is based on the rating of the circuit's fuse or circuit breaker.

In general, conductors used as equipment grounding conductors are sized from Table 250.122. Table 250.122 is based on the size of the fuse or circuit breaker that protects the circuit. As the circuit goes up in rating, a larger equipment grounding conductor is required.

The minimum size equipment grounding conductors for circuits protected by 15 amp fuses or circuit breakers is 14 AWG. Circuits protected by 20 amp and 30 amp devices must use equipment grounding conductors rated 12 AWG and 10 AWG respectively.

Starting at 40 amps, however, the required size of the equipment grounding conductor does not match the rating of the ungrounded conductors of the circuit. For example, a No. 10 equipment grounding conductor can be used with a 40 amp or 50 amp circuit. A No. 6 equipment grounding conductor is large enough for a 200 amp circuit, a No. 1 equipment grounding conductor is OK for use on a 600 amp circuit.

The equipment grounding conductors can be smaller than the ungrounded circuit conductors because the equipment grounding conductor carries current only for a short period of time before the fuse or circuit breaker operates to open the circuit. In fact, the operating time for inverse time circuit breakers is only a fraction of a second.

When the equipment grounding conductor is a raceway all connections must be made up wrench tight, with paint and rust removed to ensure good metal-to-metal connections between raceways and enclosures. Solid connections along the fault current path mean the path will be low resistance. Loose connections mean a high resistance path that will delay the operation of the fuse or circuit breaker, possibly causing more damage to equipment and property and danger to personnel.

Where conductors are installed in parallel in multiple raceways the equipment grounding conductors must be installed in parallel in each raceway. Each equipment grounding conductor must be full sized, based on the size of the overcurrent protective device for the parallel run. For example, if a feeder is protected at 800 amps, but installed in two parallel runs, each equipment grounding conductor in the parallel conduits must be a 1/0 copper, or 3/0 aluminum, based on the 800 amp overcurrent device.

If the ungrounded conductors are increased in size because of voltage drop the equipment grounding conductor must be increased in size by the same proportion. For example if the ungrounded conductors are increased by 15%, the equipment grounding conductor must be increased by 15%. The required increase in the size of the equipment grounding conductor only applies when the ungrounded conductor is increased in size to carry the load, like when conductors are up-sized because of voltage drop. If ungrounded conductors are increased in size because of more than 3 current-carrying conductors in conduit, or because of a hot ambient temperature, a larger equipment grounding conductor is not required.

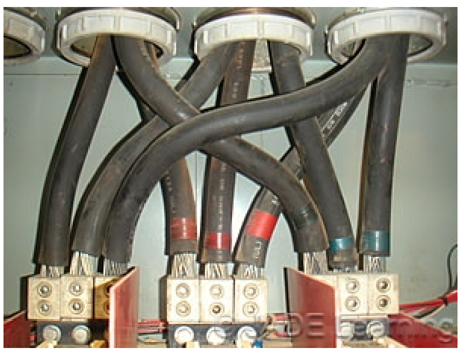
Question 54:   What is the minimum size equipment grounding conductor used on a circuit protected by a 150 amp circuit breaker?

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

Wiring Methods.

Question 55:   300.3(B)&300.3(B)(1) Conductors of the Same Circuit & Paralleled Installations.

Question ID#: 10574.0



Paralleled conductors have specific requirements.

All ungrounded and grounded conductors of the same circuit, including the equipment grounding conductors are required to be installed in the same raceway, cable tray, auxiliary gutter, cablebus assembly, trench, cord, or cable. There is one exception for conductors installed in nonmetallic reaceways run underground.

When circuit conductors are kept close together, the magnetic fields surrounding the conductors cancel each other; this reduces circuit impedance and inductive heating and improves the overall efficiency of the electrical system.

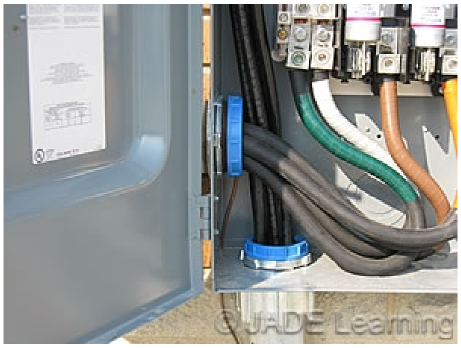
When conductors are installed in parallel in separate raceways or cables, the requirement to keep all circuit conductors together applies separately to each parallel run. Each raceway or cable of the paralleled installation is required to include a conductor from each phase and the grounded conductor and equipment grounding conductor if used. Equipment grounding conductors run in parallel raceways or cables are required to be sized in accordance with 250.122.

Question 55:   When installed in three parallel metal raceways how should the conductors be installed?

A: Phase A conductors in one conduit, phase B conductors in the second conduit, phase C conductors in the third conduit.
B: All grounded conductors together in a single conduit.
C: Each conduit should have 1 conductor from phase A, 1 conductor from phase B, 1 conductor from phase C, and the grounded conductor.
D: All conductors from phase C should be installed in a single conduit with the grounded conductors.

Question 56: 300.4(G) Insulated Fittings.

Question ID#: 10575.0



Insulating bushings are required for raceways containing #4 AWG and larger conductors.

The insulation on large conductors entering junction boxes and other enclosures can be physically damaged when the wires are pulled into the enclosure. To prevent such damage, the Code requires identified, insulated fittings on conduits containing No. 4 and larger conductors when the raceway is fastened to an enclosure.

Insulating bushings are not required for raceways containing conductors smaller than No. 4 AWG because small conductors bend easily and are not as likely to be damaged during installation.

An exception to this section permits threaded hubs and fittings with a smooth rounded or flared metal entry to protect conductors from damage.

Question 56: When installed in a conduit which is attached to an enclosure, which conductors require an insulated fitting on the conduit?

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

Question 57: 300.7 Raceways Exposed to Different Temperatures.

Question ID#: 10576.0

Sealing raceways exposed to different temperatures prevents condensation from forming inside the raceway.

When different sections of the same raceway are exposed to different temperatures, condensation forms inside the raceway itself as warm air within the raceway circulates to sections of raceway containing colder air.

Condensation in raceways is a problem where raceways pass from inside a building to the outside. It is a real problem in cold storage areas of grocery stores and food processing plants. The problem can occur in walk-in freezers and cold storage areas inside of raceways used for lighting branch circuits or fans and in raceways for control circuits.

To help prevent this problem, the Code requires that an approved material be used in the raceway to prevent the circulation of air; this is usually done at a fitting or box placed close to the boundary between the two temperature zones. While explosion-proof seal-offs like those required in hazardous locations will work to prevent air from circulating in a raceway, they are expensive and they are not required for this purpose. Many AHJs approve of inserting common fiberglass insulation in the raceway as a way of minimizing this problem.

Question 57: Raceways exposed to different temperatures shall be:

A: Identified on the plans.
B: Sealed.
C: Classified as hazardous.
D: Painted orange.

Question 58: 300.12 Mechanical Continuity - Raceways and Cables.

Question ID#: 10577.0

Continuity of metallic raceways and cable sheaths between enclosures and pull points is required.

Section 300.12 requires metallic and nonmetallic raceways, cable armor, and cable sheath to be continuous between junction boxes, cabinets, fittings, and other types of enclosures.

There are two basic reasons for this requirement: (1) It ensures the continuity of metallic raceways and cable sheaths that serve to bond and ground equipment. (2) Conductors will be less likely to be damaged when pulled into a continuous length of raceway.

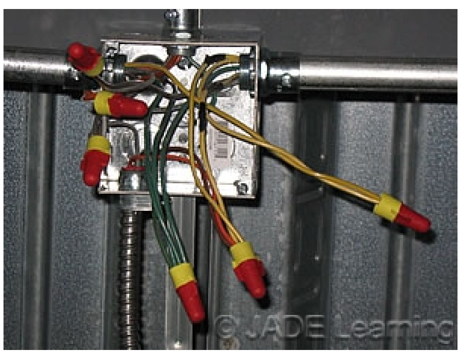
There are two exceptions to the requirement that raceways and armored cable be continuous between terminations: (1) Short lengths of raceway are permitted to be installed to protect cables from physical damage and to provide support for cables. (2) Raceways installed to enter the bottom of open bottom equipment like switchgear and motor control centers are not required to be mechanically connected to the equipment itself. Bonding jumpers are permitted to establish electrical continuity of raceways used in these installations.

Question 58: Raceways shall be ________ between cabinets and boxes.

A: Continuous.
B: Limited in length.
C: The same diameter.
D: Not over 100 feet in length.

Question 59: 300.14 Length of Free Conductors at Outlets, Junctions, and Switch Points.

Question ID#: 10578.0



At junction, pull, and device boxes enough free conductor is required for the connection of devices and for future modification of circuits.

Section 300.14 requires a minimum of 6 in. of free conductor at each junction, outlet, and switch box. The purpose of the requirement is to have long enough conductors to make splices, connect devices and luminaries.

The 6 in. of free conductor is measured from where conductors in a raceway enter the box; or in the case of cables, the free conductor is measured from the point where the outer sheath is removed.

The required length of free conductors is different for smaller boxes; if either the length or width of the opening of a junction, outlet, or switch box is less than 8 inches the conductors are required to be long enough to allow at least 3 inches of conductor to extend out of the box.

For example, the free conductor required for a device box with a 3" X 2" opening is required to extend outside the box for at least 3-inches. But conductors installed in EMT in a junction box with a 10" X 10" opening are required to be at least 6 in. long; and they do not have to extend outside the box.

An exception allows conductors to be any length if they are not spliced or terminated in the junction, outlet, or switch box.

Question 59: Conductors are installed in a junction box that measures 12 in. x 12 in. How much free conductor is required?

A: 4 in.
B: 6 in.
C: 8 in.
D: 15 in.

Conductors for General Wiring.

Question 60: 310.10(H) Conductors in Parallel.

Question ID#: 10580.0

Conductors size No. 1/0 AWG and larger are permitted to be paralleled.

The rules for parallel conductors in section 310.10(H) are organized in five sub-sections.

1. General permits ungrounded phase conductors, grounded conductors and neutrals, size 1/0 AWG and larger, to be installed in parallel.

There are two exceptions to the general rule that limit parallel conductors to 1/0 and larger:

Exception No. 1 Permits conductors smaller than 1/0 AWG to be installed in parallel to supply control power for instrumentation, relays, solenoids, and contactors and for systems operated at frequencies of 360 Hz and higher.

Exception No. 2 permits grounded neutral conductors in sizes 2 AWG and 1 AWG to be installed in parallel in existing installations when done under engineering supervision.

2. Conductor and Installation Characteristics requires that parallel conductors for each phase, neutral, or grounded conductor must have the following characteristics: they are to be identical in length, conductor material, size (AWG or kcmil), insulation type, and they must be terminated in the same manner. All phase conductors for phase A must be completely identical in all aspects, but phase A is not required to be identical to conductors used for phase B or phase C. Phase B conductors must be identical to each other but not necessarily to conductors for phase A or C. Phase C conductors must be identical to each other, but not necessarily to conductors for phase A or B.

3. Separate Cables or Raceways used for parallel installations are required to be identical in all respects. Using raceways of different materials or different diameters increases circuit impedance and damages circuit performance. Circuit breakers may be slower to trip.

4. Ampacity Adjustment requires conductor ampacity to be adjusted in accordance with 310.15(B)(3)(a) when there are more than three current carrying conductors in a raceway or cable.

5. Equipment Bonding Conductors in parallel circuits are required to be sized in accordance with 250.122.

6. Bonding Jumpers

When parallel equipment bonding jumpers or supply-side bonding jumpers are installed in raceways, they are required to be sized and installed in accordance to 250.102.

Question 60: Without using any exceptions, what is the smallest size ungrounded conductor that can be installed in parallel?

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

Question 61: 310.10(F) Direct-Burial Conductors.

Question ID#: 10581.0

Only cables and conductors identified for direct burial are permitted to be buried without being installed in a raceway.

Conductors and Cables that are suitable for direct burial are required to be identified for that specific purpose. This means that they have been evaluated for that specific purpose, function, use, environment, and application by a qualified testing laboratory like ULÂ®.

Conductors and Cables that are directly buried are subject to environmental factors such as potential damage from backfill, moisture, chemicals found in soil, burrowing rodents, mold, and fungi. Third party testing laboratories test cables identified for direct burial to ensure they can withstand the most common environmental conditions.

Cables that are rated over 2000-V must be shielded. However there are two exceptions permitting use of unshielded cables as follows:

- Exception No. 1 permits the use of unshielded multiconductor cable rated 2001 - 2400-V provided that cable includes an overall metal sheath or armor.
- Exception No. 2 permits the use of listed unshielded airfield lighting cable to be used in circuits rated up to 5000-V in circuits powered by regulators.

Regardless of whether the cables are shielded or unshielded, if they are used for direct burial, they are required to be identified for that specific purpose.

Question 61: Which of the following statements about direct burial-conductors is a true statement?

A: Direct burial conductors must be identified as suitable for direct burial.
B: Direct-burial conductors must have a metallic sheath.
C: Direct-burial conductors listed for use over 1000 volts must be shielded.
D: Direct-burial conductors cannot be installed in conduit.

Question 62: 310.10(D) Locations Exposed to Direct Sunlight.

Question ID#: 10582.0

Only cables and conductors listed as sunlight resistant are permitted to be exposed to direct sunlight.

Natural sunlight can damage rubber and various synthetic materials such as plastic and vinyl that are not designed to withstand the ultraviolet rays in sunlight. The insulation and outer sheath of conductors and cables like Nonmetallic-Sheathed Cable that are listed for use in interior locations will be degraded over time if installed where they are exposed to sunlight.

Section 310.10(D) requires that conductors and cables that are installed where they are exposed to direct sunlight must be listed, or listed and marked, as being sunlight resistant; or covered with insulating material, such as tape or sleeving, that is listed, or listed and marked, as being sunlight resistant.

Some cables and conductors listed and identified for direct burial such as UF cable are also suitable for exposure to sunlight. However, UF cable that is suitable for exposure to sunlight is generally marked indicating it is suitable for exposure to sunlight. If it is not marked as suitable for direct sunlight, don't assume that it is.

Unfortunately there is not a convenient system of letters to identify conductors and cables suitable for exposure to direct sunlight. Unless it is physically marked on the cable or conductor, referring to the ULÂ® "White Book" is the best way to determine if a cable or conductor is suitable for exposure to sunlight.

Question 62:   Insulated conductors where exposed to direct rays of the sun shall comply with one or more of the following. Which item is not required?

A: Listed as being sunlight resistant.
B: Suitable for direct burial
C: Marked as being sunlight resistant.
D: Covered with insulating material listed as being sunlight resistant.

Outlet, Device, Pull and Junction Boxes.

Question 63: 314.28 Pull and Junction Boxes and Conduit Bodies.

Question ID#: 10584.0

Select pull boxes, junction boxes and conduit bodies for conductors 1000-V and less in accordance with 314.28.

For system voltages of 1000 volts and less, the dimensions of pull and junction boxes containing insulated conductors size No. 4 AWG and larger are required to comply with section 314.28. The required size of the box is based on the size and number of raceways that enter the box and on whether the pull is straight thru the box or whether the raceways enter the box at an angle.

If raceways containing No. 4 AWG or larger conductors enter a box on opposite sides of the box, it is a ***straight-pull*** with conductors passing straight thru the box. To calculate the minimum required length of the box for a straight pull, the Code requires that the distance between the two sides where the raceways enter the box be not less than eight times the trade size of the largest raceway containing the conductors.

For example, if a 3 inch RMC raceway containing 4/0 THHN conductors was used for a straight pull, the minimum length of the box (side A) is 24-in. (3 in. X 8 in = 24 in.). The straight pull calculation determines the ***minimum length*** of the box; oversizing pull or junction boxes is common for ease of installation.

Section 314.28(A)(2) Angle or U Pulls, or Splices requires the distance between raceways containing the same conductors to be separated by a distance of at least 6 times the diameter of the larger raceway.

Question 63: A 480 volt, 200 ampere feeder is installed in 2 inch EMT. What is the minimum length of the box for a straight pull when the conductors are not spliced?

A: 10 inches.
B: 12 inches.
C: 14 inches.
D: 16 inches.

Question 64: 314.71 Over 1000 Volts. Size of Pull and Junction Boxes, Conduit Bodies, and Handhole Enclosures.

Question ID#: 10585.0

Select pull boxes for conductors over 1000-V in accordance with 314.71.

Pull and junction boxes for conductors supplied by system voltages over 1000 volts are required to be much larger than boxes used where the voltage does not exceed 1000 volts because the insulation and shielding used for medium and high-voltage conductors makes the conductors thicker and harder to work with.

In addition to being larger, the minimum size of boxes for straight and angle pulls is based on the outer ***diameter*** of the cables themselves, not on the size of the raceway. Larger boxes are required for shielded and lead covered conductors than for those that are not shielded.

If high voltage conductors enter and exit a box on opposite sides, it is a "straight-pull" as shown in this illustration. If shielded or lead covered conductors are used the minimum length of length of the box for a straight pull is 48 times the outside diameter of the outer sheath of the largest conductor or cable pulled thru the box. For example, if a shielded conductor had an outer diameter of 1.25 in., the minimum length of a box for a straight pull is 60 in. (1.25 in. X 48 = 60 in).

If non shielded conductors are used in a straight pull, the minimum length of the box is 32 times the outer diameter of the largest conductor or cable. For example, if the outer diameter of a non-shielded conductor was 1.25 in., the minimum length of the box is 40 in. (1.25 in. X 32 = 40 in.).

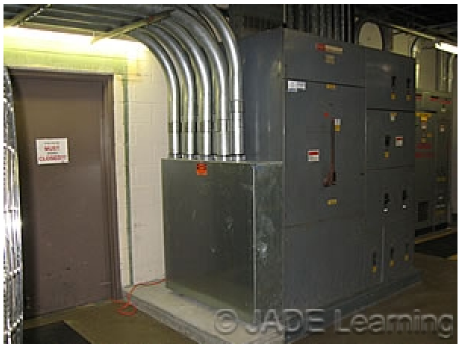
Conduit bodies can be used as pull and junction boxes if they meet the dimensional requirements for boxes.

Question 64: What is the minimum length of a high voltage pull box used for a straight pull when the largest conductor entering the box is a shielded conductor and is 1 inch in diameter?

A: 24 inches.
B: 36 inches.
C: 48 inches.
D: 60 inches.

Question 65: 314.72(D) Wiring is Accessible.

Question ID#: 10586.0



Working space requirements for high-voltage pull boxes, junction boxes, and conduit bodies is shown in 314.72 (D).

Pull and junction boxes for conductors exceeding 600 volts are required to be installed so that the wiring is available without any part of the building being removed. The requirements for work space are shown in 110.34. Dimensions required for work space in Table 110.34(A) are based on three different sets of working conditions that vary depending on how close the work space is to exposed energized components and to grounded surfaces.

Three factors that affect the depth of work space for high and medium voltage pull and junction boxes are specified in section 110.34. The depth of work space varies with the following: (1) System voltage. (2) How close the work space is to exposed energized components. (3) How close the work space is to grounded surfaces.

In a condition No. 1 situation, for system voltages between 601 - 2500 volts, the minimum depth of the work space required is 3 ft. for a pull box because the work space is not next to either energized parts or a grounded surface. However, if the voltage were between 2501 - 9000-V the minimum depth of work space required is 4 ft for a condition No. 1 situation.

In a condition No. 2 situation, for system voltages between 601 - 2500 volts, the minimum depth of the work space required for a pull box where there are energized parts on one side of the work space and a grounded surface on the other is 4 ft.. However, if the voltage is between 2501 - 9000 volts the minimum depth of work space required is 5 ft.

The grounded surfaces in condition No. 2 situations include concrete, brick, or tile walls as well as grounded equipment enclosures, metallic raceways, and grounded structural steel.

Question 65: What is the minimum depth of the work space for a high voltage pull box where there are no energized parts or grounded surfaces close to the box (condition 1) and the voltage is 2300 volts?

A: 6 ft.
B: 5 ft.
C: 4 ft.
D: 3 ft.

Question 66: 314.72(E) Suitable Covers.

Question ID#: 10587.0

Covers for high-voltage pull and junction boxes must provide a warning about the dangers of high voltage conductors and equipment.

Because high and medium voltage installations can be extremely dangerous to personnel, the Code requires covers for junction and pull boxes to be securely fastened in place. In addition to requiring covers to be secured in place, the Code also requires a warning to be placed on the outside of covers of junction and pull boxes to alert personnel to the danger within the box. The warning label is required to be clearly and permanently marked with block letters at least 1/2 inch high as follows:

DANGER - HIGH VOLTAGE - KEEP OUT

Self-adhesive warning labels like the one in this illustration are available from a number of companies. These labels comply with the requirements of 314.72(E).

On underground boxes, covers weighing more than 100-pounds are considered to be secured in place by their weight; no additional means are required to secure these heavy covers. However, they too are required to be clearly and permanently marked with block letters at least 1/2 inch high as follows: DANGER - HIGH VOLTAGE - KEEP OUT

Question 66: Covers for high voltage boxes shall be marked:

A: High voltage.
B: Keep out.
C: Danger - High voltage.
D: Danger - High voltage - Keep out.

Conduit and Raceways.

Question 67: 344.22 Number of Conductors.

Question ID#: 10589.0

Rigid Metal Conduit, as well as other types of conduit, can be filled to 40% of the cross-sectional area of the conduit.

The number of conductors permitted in Rigid Metal Conduit is determined by Table 1 of Chapter 9. That Table requires conduit and Tubing to be filled to not more than 40% of the cross-sectional area of the conduit.

Annex C lists the number of conductors that are permitted in different types of conduit and is based on the 40% fill requirement of Table 1, Chapter 9. For example, Informational Annex C8 is used for Rigid Metal Conduit. According to Informational Annex C8, if 4/0 AWG type THHN conductors are used, 4 conductors are permitted to be installed in a 2 in. RMC, 6 conductors are permitted to be installed in a 2 1/2 in. conduit, and 9 conductors are permitted to be installed in a 3 in. conduit.

If different size conductors are used in the same conduit, the number of conductors permitted must be calculated from Table 4 and Table 5 in Chapter 9. This calculation is complicated and is a favorite question on state licensing exams.

Question 67: What is the proper procedure to follow when installing conductors in conduit?

A: Use the Tables in Chapter 9 and Annex C to select the correct number of conductors.
B: Fill the conduit to 80% of its inside diameter.
C: Increase the pulling force until the conductors are installed in the conduit.
D: Save time by increasing the number of conductors in a conduit run.

Question 68: 344.30 Securing and Supporting.

Question ID#: 10590.0

Rigid metal conduit shall be secured and supported in accordance with 344.30.

Rigid Metal Conduit (RMC), as well as other raceway systems, is required to be installed as a complete system. It must be firmly fastened in place, supported at intervals not exceeding 10 ft., and secured within 3 ft. of where it is terminated. There are two cases where these requirements are relaxed to provide for situations that make it difficult, if not impossible, to comply with this section.

In locations where the building or structure does not permit securing RMC within 3 ft. of where it is terminated, the 3 ft. requirement is relaxed allowing support to be placed up to 5 ft. from the termination. This is particularly helpful in factories and warehouses where luminaires are hung on the trusses and RMC is run at right angles to trusses spaced 10 ft. or more apart.

Supports for straight runs of RMC are determined from Table 344.30(B)(2).

Exposed vertical risers from industrial machinery or fixed equipment are permitted to be supported every 20 ft. if threaded couplings are used and the conduit is supported at the top and bottom of the riser.

Question 68: How close to an outlet box is rigid metal conduit required to be supported?

A: 1 ft.
B: 18 inches
C: 3 ft.
D: 6 ft.

Question 69: 352.10(F) Exposed.

Question ID#: 10591.0

PVC conduit providing protection from physical damage must be Schedule 80.

PVC conduit is permitted to be installed in exposed locations, but it is not permitted to be installed where it is exposed to physical damage unless it is identified for use in areas where it may be subject to physical damage. Schedule 40 PVC is not identified for use where subject to physical damage.

An Informational Note in section 352.10 indicates that ***schedule 80 rigid polyvinyl chloride conduit (PVC) conduit is identified for use where subject to physical damage***. The primary difference between schedule 40 and schedule 80 PVC is that the wall of schedule 80 PVC conduit is significantly thicker making it stronger and better able to withstand physical abuse.

Although both Schedule 40 and Schedule 80 are suitable for exposure to sunlight, rain, direct burial, and for being embedded in concrete, in areas where the raceway is subject to physical damage, use schedule 80 not schedule 40 PVC conduit.

Question 69: Schedule 40, rigid polyvinyl chloride conduit (PVC) shall be permitted for exposed work where not subject to _______.

A: Rain.
B: Physical damage.
C: Sunlight.
D: Corrosion.

Question 70: 352.30(B) Supports.

Question ID#: 10592.0

Install supports for PVC raceways in accordance with table 352.30.

Rigid polyvinyl chloride conduit (PVC) is required to be installed as a complete system and supported in accordance with the spacing requirements in Table 352.30.

Table 352.30 requires supports to be closer together for smaller conduit than for larger conduit. Although PVC conduit is required to be secured, it is also required to be installed to allow for the movement caused by large differences in the outside temperature.

Because the same trade size PVC conduit is not as strong as a metallic conduit, its supports are required to be much closer together. For example, supports for 2 inch RMC are required every 10 ft. The maximum spacing in Table 352.30 between supports for 2 inch PVC is 5 ft.

PVC conduit is required to be secured within 3 ft. of where it is terminated.

Section 352.30(C) permits unsupported short sections of PVC up to 18 inches long between terminations, provided that the PVC does not include a coupling and that it is not terminated in concentric or eccentric knock-outs. This is particularly helpful where nipples are run between enclosures or panelboards.

Question 70: What is the minimum number of supports needed in a 10 ft. run of 2 inch PVC between two junction boxes?

A: 1.
B: 2.
C: 3.
D: 4.

Question 71: 352.44 Expansion Fittings.

Question ID#: 10593.0

Expansion fittings prevent damage to PVC caused by temperature changes.

PVC conduit expands and contracts lengthwise as the temperature changes. If the length of the conduit will change 1/4 inch or more, expansion fittings are required in straight runs between boxes, cabinets, and other types of conduit terminations.

If PVC is installed without expansion fittings in warm weather, when the weather turns cold, the PVC's contraction can pull raceways out of fittings and enclosures. On the other hand, if PVC is installed when it is cold, when the weather turns warm the expansion will cause the conduit to bend as it expands which can break or loosen supports.

Table 352.44 gives the length that PVC will change with variations in temperature.

For example, if a straight run of 100-feet of PVC conduit is installed in the summer when it is 90Â°F in an area where winter temperatures of 30Â°F are common, from summer to winter the PVC will experience a temperature change of 60Â°F. According to Table 352.44 the overall length of the conduit will contract (shrink) 2.43-inches. If the run were only 50-feet long, it would shrink half that much or 1.215-inches.

Question 71: When are expansion fittings for PVC conduit required?

A: If the PVC conduit will expand or contract 1/4 inch or more.
B: Every 50 ft. in a straight run of PVC conduit.
C: Every 100 ft. in a straight run of PVC conduit.
D: In underground installations.

Flexible Cords and Cables.

Question 72: 400.5 Ampacities for Flexible Cords and Cables.

Question ID#: 10595.0

Use tables 400.5(A)(1) & (2) to determine the ampacity of flexible cords and cables.

The ampacity of flexible cords and cables is selected from Table 400.5(A)(1) and Table 400.5(A)(2). The Tables are based on an ambient temperature of 86 degrees F and not more than 3 current carrying conductors in the cord or cable. If the surrounding temperature is other than 86 degrees F, or there are more than 3 current carrying conductors in conduit the ampacity of the cord or cable must be adjusted.

The more common types of cord and cable, such as SO and SJO cord, are in Table 400.5(A)(1). There are two columns in Table 400.5(A)(1). The ampacity of a cord is taken from Column A if there are 3 current-carrying conductors in the cord. The ampacity of a cord is taken from Column B if there are 2 current-carrying conductors in the cord.

From Table 400.5(A)(1). Ampacity of Common Types of Thermoset and Thermoplastic Cords and Cables.

Size (AWG)

Column A

Column B

16

10

13

15

12

16

14

15

18

12

20

25

10

25

30

Question 72: What is the ampacity for each of 3, No. 10 current carrying conductors in a Type SO cord?

A: 20 amperes.
B: 25 amperes.
C: 30 amperes.
D: 35 amperes.

Question 73: 400.7 Uses Permitted.

Question ID#: 10596.0

Flexible cords have many uses.

Flexible cords and cables are used where flexibility is necessary for the operation and use of the equipment. Flexible cords and cables are permitted to be used for:

- pendants
- portable luminaires
- portable appliances
- portable tools
- electric vehicle charging
- mobile signs
- elevator control and lighting and dumb waiters
- hoists and cranes
- equipment that is frequently moved
- equipment that has parts that move while in use

Also, an existing receptacle outlet can be connected to a power inlet which provides power to an additional single receptacle outlet. This is sometimes used to provide power to flat screen TVs so there are no exposed wires.

In general, where flexible cords are used with appliances, tools, or equipment that is frequently changed or moved, the cord is required to be equipped with an attachment plug. Power is required to be supplied from a receptacle.

An exception permits cord connected equipment to be connected to a busway without plugs or receptacles.

Question 73: Where are flexible cords permitted to be used?

A: Attached to buildings.
B: Run through holes in walls.
C: Concealed in walls.
D: As pendants.

Question 74:   400.8 Uses Not Permitted.

Question ID#: 10597.0

The photograph shows a violation of section 400.8, uses not permitted for flexible cords and cables.

Flexible cords and cables are never permitted to be used as a replacement for permanent wiring methods.

The following uses are specifically prohibited in 400.8:

- as a replacement for permanent wiring
- installed running thru windows or doorways
- installed thru holes in floors, walls, dropped ceilings or structural ceilings
- installed where it is subjected to physical damage
- installed where it is hidden from view by floors, ceilings, walls, or other structures
- installed in raceways unless permitted elsewhere in the Code
- installed secured to the surface of structures or buildings except for branches from busways as permitted in 368.56(B)

Question 74:   Flexible cords shall not be used for:

A: Fixed wiring of a structure.
B: Wiring of fixtures.
C: Wiring of cranes.
D: Pendants.

Switchboards and Panelboards

Question 75:   408.3(A)(3) Same Vertical Section.

Question ID#: 10599.0

Unless separated by a barrier, wiring within a vertical section is required to be terminated within that section.

Other than control wiring, only those conductors that are terminated within a vertical section of a switchboard are permitted to be within that vertical section. Control wiring is permitted to be within the vertical section with equipment that the control wiring is associated with. For example, the control wiring for a shunt-trip circuit breaker is permitted in the same vertical section with the shunt-trip breaker itself; otherwise the breaker could not be operated.

The purpose of permitting only those conductors in a vertical section that are terminated within that section is to prevent conductors from being accidentally energized by contact with busbars or energized circuit breakers from another vertical section.

An exception permits conductors to pass horizontally through vertical sections of switchboards where they are not terminated and the conductors are isolated from the busbars by a barrier. Horizontal travel of conductors thru vertical sections of a multi-section switchboard is required when a raceway is attached to a switchboard in a section other than the one where the conductors will be terminated.

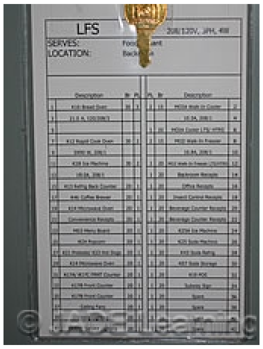
Question 75:   Which of the following statements about conductors and busbars on a switchboard, switchgear, or panelboard is true?

A: Without using the exception, all conductors entering a section of a switchboard must terminate in that same verticle section.
B: The exception allows conductors to travel horizontally through vertical sections of a switchboard without being isolated from busbars by a barrier.
C: Conductors can only travel horizontally through vertical sections of a switchboard in an industrial facility.
D: If only qualified persons will service the installation, conductors can travel horizontally through vertical sections of a

switchboard.

Question 76: 408.4 Circuit Directory or Circuit Identification.

Question ID#: 10600.0



Circuit directories are required to clearly identify the purpose of each circuit.

Switchboards, switchgear, and panelboards are required to have a circuit directory that clearly identifies the purpose of each circuit. This requirement is basic to the safe and efficient operation and maintenance of electrical equipment in all types of facilities.

Directories shall be provided at the time of initial installation and they must be updated when circuits are modified or added. Circuits that are in use are required to be identified. Spare circuit breakers are required to be identified as spares.

The directory information is required to be located on the face of a panelboard or switchboard or on the inside of the door. The circuit position (number) is identified for each circuit breaker. The identification of circuits is required to be legible, clear, and evident as to its purpose and use.

The identification is required to be stated with an approved level of detail that allows people to distinguish each circuit from all other circuits. For example, identifying a circuit as north parking lot lights would be adequate unless there were two parking lots on the north side of a building.

All switchboards, switchgear, 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.

Question 76: Which circuit is properly identified in a panelboard circuit directory?

A: Lights.
B: Receptacles.
C: Maintenance Shop Welding Receptacle.
D: Main level receptacles.

Question 77: 408.36(D) Back-Fed Devices.

Question ID#: 10601.0

Plug-in back-fed OCPDs are required to be fastened by clips or other means to the panel they supply.

Back-fed circuit breakers are often used in main-lugs only (MLO) sub-panels supplied from a main panel. In such installations, the back-fed circuit breaker functions as the main disconnect for the sub-panel. When back-fed circuit breakers are installed for this purpose, the Code requires them to be secured to the sub-panel so that the breaker cannot be intentionally removed from the sub-panel without first removing the clamp or other means used to secure the back-fed device. To remove the back-fed circuit breaker, you have to first remove the clamp or fastener.

When conductors are terminated on a back-fed device, the conductors themselves can sometimes exert enough pressure on the unsecured plug-in back-fed device to loosen the connection between the back-fed breaker and the busbars of the sub-panel. When this happens, damaging arcs can occur between the clips on the back-fed breaker and the busbars. The sub-panel can be de-energized if the back-fed circuit breaker becomes completely disconnected. Securing the back-fed device to the sub-panel prevents these conditions.

Question 77: Which of the following statements about plug-in type, back-fed circuit breakers is true?

A: The plug-in, back-fed circuit breaker cannot exceed 100 amperes.
B: The plug-in, back-fed circuit breaker must be secured in place by an additional fastener.
C: The plug-in, back-fed circuit breaker must be mounted in the vertical position.
D: The plug-in, back-fed circuit breaker must be mounted in the horizontal position.

Motors, Motor Circuits, and Controllers.

Question 78: 430.6 Ampacity and Motor Rating Determination.

Question ID#: 10603.0

The full load current rating of motors is used to select branch circuit and feeder wire size, and overcurrent protection.

The full-load current for motors and equipment covered in Article 430 is based on the Full-Load Current Tables in Article 430 rather than on the full load current marked on the motor nameplate itself. The full-load current tables provide ampacity for motors based on the operating voltage and horsepower rating of the motors:

- Table 430.247 covers DC motors
- Table 430.248 covers single-phase AC motors
- Table 430.249 covers two-phase, 4-wire AC motors
- Table 430.250 covers 3-phase AC motors

The ampacity of conductors supplying some types of motors is not selected from the Tables in Article 430. These motors include low speed and high torque motors, multispeed motors, and AC motors supplied by adjustable voltage, variable torque drive systems.

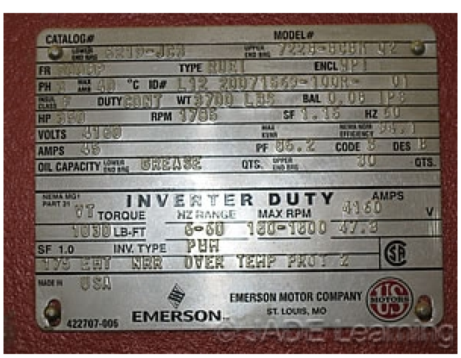
Motor overload protection is always selected from the motor nameplate rating.

Question 78: How is the full-load current selected for the most common single-phase and 3-phase AC motor applications?

A: The Full-Load Current Table values of Article 430.
B: The nameplate on the motor.
C: The motor manufacturer's recommendation.
D: Charts provided with the motor control center.

Question 79: 430.7 & 430.8 Marking on Motors, Multimotor Equipment, and Controllers.

Question ID#: 10604.0



The marking requirements for motors and controllers are specified in 430.7 & 430.8.

Section 430.7 lists fifteen different categories of information that are required to be marked on a motor's nameplate. Motors having the feature(s) indicated below are required to provide the following information on the nameplate:

- Manufacturer's name or ID mark
- The motor's current and voltage
- The number of phases and frequency for AC motors
- Rated full-load RPM
- Rated ambient temperature and rated temperature rise
- Rated duty cycle: continuous, 60, 30,15,or 5 minutes
- HP of constant speed motors rated 1/8th HP or more; for multispeed motors rated 1/8th HP or more the rated HP for each speed
- locked-rotor amperage or Code letters of AC motors rated 1/2 HP or more
- Design letter indicating a motor's speed/torque characteristic curve for design B, C, or D motors. Design letters are not the same as letter codes used to indicate locked rotor current

- For wound-rotor induction motors: secondary voltage and full-load current
- For synchronous motors: DC field current and voltage
- Type windings for DC motors over 7-inches in diameter: (shunt, compound, or series wound)
- For motors with integral thermal protection: "Thermally Protected" or on motors rated at less than 100 Watts or less "T.P."
- For impedance protected motors: "Impedance Protected"; motors rated 100 watts or less are permitted to be marked "Z.P
- Motors with electric condensation prevention heaters are required to be marked to indicate the heater voltage, phases, and wattage

The general requirements in section 430.8 require motor controllers to be marked with the manufacturer's name or identifying mark, the rated current, voltage, and Horse Power, and the short circuit current rating. Four exceptions specify circumstances under which the short-circuit rating is not required to be marked on controllers.

Question 79:   Which of the following is not required to be marked on a motor nameplate?

A: Rated volts.
B: Full load current.
C: Rated full load speed.
D: Rated horsepower if less than 1/8.

Question 80:   430.22 Single Motor.

Question ID#: 10605.0

The minimum ampacity of circuits for continuous duty motors is 125% of the Full-Load Current table values in Article 430.

Branch circuit conductors supplying motors used in continuous duty applications are rated for 125% of the motor's full load current rating, as listed in the full-load current tables in Article 430.

Whenever current flows through a conductor, some heat is naturally generated. Increasing the ampacity of the conductors that supply continuous duty motor loads means that the conductors will operate at a lower temperature and reduce the possibility that heat from the conductors will get transferred to the terminals, causing them to overheat. We increase the size of conductors for continuous loads so the terminals will not be damaged.

To find the correct size wire for a continuous duty motor multiply the full load current by 125%.

For example, determine the minimum size copper, THWN conductor required for a continuous duty, 10-HP, 230-V, single phase squirrel-cage induction motor. Assume all terminations are rated for 75Â°C.

Step 1. Find the ampacity rating for the motor in table 430.248. The full-load current rating for the motor is 50 amps.

Step 2.   Increase the motor's ampacity for continuous duty by multiplying the ampacity from the table by 125%: 50 X 1.25 = 62.5 amps.

Step 3. From table 310.15(B)(16), using the 75Â°C column, select the smallest size conductor rated for at least 62.5 amps. Select a No. 6 AWG copper conductor.

Question 80: A continuous duty, 10 horsepower, 208 volt, 3-phase motor has a full load current of 30.8 amps. What is the minimum rating of each of the conductors that supply the motor?

A: 30.8 amps.
B: 38.5 amps.
C: 42.6 amps.
D: 53.9 amps.

Question 81: 430.24 Several Motors or a Motor(s) and Other Load(s).

Question ID#: 10606.0

The minimum ampacity of feeders supplying several motors is calculated from Section 430.24.

Conductors supplying several motors or a motor(s) and other loads cannot be less than the sum of the following:
1. 125% of the full-load current rating of the highest rated motor.
2. The sum of the full-load current ratings of all other motors in the group.
3. 100% of the noncontinuous non-motor load.
4. 125% of the continuous non-motor load.

The NEC requires the full-load current (FLC) from the tables in Article 430 to be used rather than the motor's nameplate FLC. The values in the tables are permitted for nominal system voltages of 110, 120, 220, 240, 440, 480, 550, and 600 volts. For example, the FLC for a 3-phase squirrel-cage induction motor with a name plate voltage rating of 460 volts is given in the 460 volt column even though the actual system voltage may be either 440 volts or 480 volts.

Feeder ampacity calculation example: Calculate the minimum ampacity of a feeder that supplies three, 460 volt, 3-phase, squirrel cage induction motors: a 20-HP, a 71/2-HP, & a 5-HP motor.

Step 1. Use table 430.250 to find full-load current (FLC) for all 3 motors:
FLC of three motors: 20-HP = 27 amps; 7 1/2 -HP = 11 amps; 5-HP = 7.6 amps.

Step 2. Multiply largest motor's FLC X 1.25 : 27 amps X 1.25 = 33.75 amps.

Step 3. Add 125% of the largest motor's FLC to the FLC of the other motors: 33.75 amps + 11 amps + 7.6 amps = 52.35 amps. Round down to 52 amps per 220.5(B).

Step 4. The minimum ampacity of the feeder supplying the three motors is 52 amps.

Summary: a feeder supplying several motors must have an ampacity not less than 125% of the largest motor's full load current (FLC) plus the FLC of the other motors in the group, plus the total of other loads operated at the same time.

Question 81: What is the minimum circuit ampacity for a motor feeder that supplies three, 208-V, 3-phase squirrel-cage induction motors where the motors are rated for 16.7 amps, 30.8 amps, and 46.2 amps?

A: 77 amperes.
B: 100 amperes.
C: 105 amperes.
D: 117 amperes.

Question 82: 430.32 Motor and Branch-Circuit Overload Protection. General.

Question ID#: 10607.0

Motor overload protection is required unless it introduces additional hazards.

Part III of Article 430 describes the requirements for motor overload devices designed to protect motors from being damaged by overloads. Motor overload devices are not designed to provide motor branch circuit short circuit or ground fault protection.

Overloads, as defined in article 100, occur when motors are operated in excess of their full load rating. When overloaded, a motor draws excessive current. Correctly sized overload devices are designed to protect motors, motor controls, and motor branch circuit conductors from being damaged by overloads. Motor overload devices include overload relays, electronic adjustable trip overloads, bimetallic elements and resettable melting alloy devices commonly called "heaters."

When selected from Part III of Article 430, overload devices are adequate to handle a motor's normal starting current and to provide protection from damage to windings caused by abnormally high currents. Overloads are caused by conditions such as: single-phasing a 3-phase motor, excessive mechanical load, excessive friction resulting from improper lubrication, improper belt or chain alignment, locked rotor.

Overload protection is not required if using it "***might introduce additional or increased hazards, as in the case of fire pumps."***

Motor overloads are usually selected to match the motor controller. If an Allen-Bradley motor starter is used, Allen-Bradley overloads are selected from the Allen-Bradley catalog.

Section 430.32 requires motor overloads for continuous-duty motors rated more than 1 horsepower to be sized at 125% of the nameplate full-load current if the motors have a marked service factor of 1.15 or greater, or the temperature rise is 40 degrees C or less. The overloads for all other motors are sized at 115% of the motor nameplate full-load current rating.

However, section 430.32(C) permits the size of the overload device to be increased to 140% for motors with a marked service factor of 1.15 or an temperature rise 40 degrees C or less if the motor will not start or run with the overloads sized at 125%. For "all other motors" the maximum value of the overloads can be increased to only 130%.

Question 82: The full-load current rating on a motor nameplate is 80 amps. The motor is marked with a service factor of 1.15. What is the rating of the overloads?

A: 80 amps
B: 90 amps
C: 100 amps
D: 105 amps

Question 83:   430.52 Rating or Setting for Individual Motor Circuit.

Question ID#: 10608.0

Overcurrent Protective devices are required to be sized in accordance with 430.52.

Motor branch circuit short-circuit and ground fault protection is covered in Part IV of Article 430. A fuse or circuit breaker protecting a single motor is required to carry the motor starting current, which can be as much as 6 times the full-load current rating of induction motors. The size of the fuse or circuit breaker is based on a percentage of full-load current selected from Table 430.52 according to the type of overcurrent protective device used.

The maximum percentage of motor Full Load Currents from Table 430.52 which are used to select branch-circuit and ground-fault protection for single-phase, squirrel-cage induction motors, and polyphase motors other than Design B, synchronous, and wound-rotor motors are as follow:

- 300% for Nontime Delay Fuses
- 175% for dual element (Time Delay) Fuses
- 800% for Instantaneous Trip Breakers
- 250% for Inverse Time Breakers

There are two important exceptions: Exception No. 1 permits the next higher standard size fuse or circuit breaker to be used if the calculation results in a value between standard sizes. Exception No. 2 permits the fuse or circuit breaker to be increased beyond the next standard size if the motor will not start.

When used in solid-state motor controller systems, semiconductor fuses for the protection of electronic devices are permitted. Semiconductor fuses are extremely fast-acting fuses and provide a high level of protection for sensitive electronic equipment. Information about the type and rating of replacement fuses must be marked next to the semiconductor fuses.

Question 83:   Without using exceptions, what is the maximum rating of a dual element (time-delay) fuse used to protect a motor with a full-load current of 100 amps?

A: 100 amps.
B: 150 amps.
C: 175 amps.
D: 200 amps.

Question 84: 430.53 Several Motors or Loads on One Branch Circuit.

Question ID#: 10609.0

Overcurrent Protective Devices for several motors on one branch circuit are sized according to 430.53.

Multiple motors are permitted by the NEC to be installed on one branch circuit. Let's look at some examples.

(1) Two or more motors, each not exceeding 1hp, are permitted to be supplied by a single 120 volt branch circuit rated at not more than 20 amps and protected by fuses or inverse time circuit breakers.

(2) Two or more motors, each not exceeding 1hp, are permitted to be supplied by a branch circuit rated up to 1000 volts at not more than 15 amps and protected by fuses or inverse time circuit breakers.

Notice the electrician is given the liberty to go as high as a 20 amp overcurrent device if the branch circuit voltage does not exceed 120 volts, but from 121 volts to 1000 volts the circuit cannot exceed 15 amps.

In either case, the electrician is also required to meet these other conditions:

a. The full-load rating of each motor cannot exceed 6 amps.

b. The rating of the branch circuit, short circuit, and ground fault protective device marked on any of the controllers is not exceeded.

c. Individual overloads are required and must conform to 430.32.

Examples of Multiple Motors

The photo shows a circulating pump for a water heater. Additional circulating pumps can be installed on the same 120 volt, 20 amp circuit if each motor is 1 horsepower or less, rated not over 6 amps, and each motor has overload protection, and the fuse or circuit breaker is not larger than the rating marked on the controller - if equipped.

Another example of several motors on one branch circuit is small exhaust fans mounted on a roof. If each motor draws 6 amps or less, has overload protection, and the overcurrent protection for the circuit is not greater than the rating of any of the controllers, the motors can be installed on a single, 120 volt, 20 amp circuit.

For circuits rated 1000 volts and less, the overcurrent protection for a circuit with multiple motors can be rated not more than 15 amps, if all the conditions for 120 volt circuit are met.

When several motors are supplied by one branch circuit, individual motors are permitted to be supplied by tap conductors that are tapped (connected) to the branch circuit conductors.

Question 84: Which of the following installations is permitted to have more than a single motor on a branch circuit?

A: 3 motors, rated 3 amps, 5 amps and 7 amps.
B: 2 motors without overload protection.
C: 3 motors connected on a single 30 amp circuit.
D: 2 motors, each with thermal protection and rated 4 amps each.

Question 85: 430.94 Overcurrent Protection.

Question ID#: 10610.0

An overcurrent protective device is required to protect the busbars in a motor control center. Individual circuits within the MCC also are protected.

Motor Control Centers (MCC) must have overcurrent protection. A fuse or circuit breaker is required to protect the motor control center common busbars. The rating of the fuse or circuit breaker cannot be greater than the rating of the busbars.

Individual motor circuits within the motor control center require overcurrent protection, but the motor control center itself is protected by an overcurrent device whose rating is set to be equal to or less than the rating of the bus that carries the whole load from the MCC.

The overcurrent protection that protects the MCC busbars is provided by (1) an overcurrent protective device located ahead of the motor control center or (2) a main overcurrent protective device located within the motor control center.

Question 85: The busbars in a motor control center that carry the whole load of the MCC are rated 800 amps. What is the maximum rating of a fuse or circuit breaker that protects the motor control center?

A: 600 amps.
B: 800 amps.
C: 1000 amps.
D: 1200 amps.

Question 86: 430.102(A) Disconnecting Means. Controller.

Question ID#: 10611.0

The disconnect for a motor controller shall be within sight from the controller.

Each motor controller must have a disconnecting means and the disconnect must be within sight from the controller. "Within sight from" as defined in Article 100 requires that the disconnect is visible from the controller and is within 50 feet of the controller.

There are three exceptions to this requirement:

Exception No. 1 permits the disconnecting means for motor circuits over 1000 volts to be out of sight of the controller provided the disconnect can be locked in the open position and that the controller has a warning label stating the location of the disconnect. The locking device is required to remain with the disconnect whether or not the lock is present.

Exception No. 2 permits a single disconnect for several controllers that control different parts of a single machine provided that both the controllers and disconnect are within sight of the machine they control.

Exception No. 3 permits the disconnect for a valve actuator motor (VAM) to be located out of sight of the VAM if locating the disconnect within sight of the VAM creates additional hazards, such as in a classified location. The exception requires the VAM to be marked indicating the location of its disconnect. The disconnect must be capable of being locked in the open position, and provisions for attaching a lock are required to be a permanent part of the disconnect.

Question 86: Without using any exceptions, what is the location for a motor controller disconnecting means?

A: Immediately adjacent to the controller.
B: Within sight of the controller.
C: Located in a motor control center.
D: Located within 100 feet of the controller.

Question 87: 430.102(B) Disconnecting Means. Motor.

Question ID#: 10612.0

Excluding exceptions its disconnect shall be located within sight from a motor.

Unless one of the two exceptions to the general rule applies, a motor is required to be provided with a disconnect located within sight from the motor.

The motor ***controller*** disconnecting means can also serve as the disconnect for the motor as long as the controller disconnect is in sight from the motor and the machinery that is controlled by the motor.

A disconnect that can be locked in the open position and is not within sight of the motor can serve as the motor disconnect under either of two conditions:

(1) Locating the disconnect within sight of the motor and its driven machinery is impracticable or creates other or greater hazards for people or property.

(2) In an industrial facility, there are written safety procedures including lockout/tagout procedures and supervision and maintenance to ensure that equipment is serviced only by qualified individuals.

Motors are required to have disconnecting means within sight of the motor, unless the controller disconnect can serve as the disconnecting means, or the motor is in a location covered by the exception. Regardless of its type or location, motor disconnects are never permitted to be automatically closed.

Question 87: Which of the following statements about a motor disconnecting means is true?

A: A conveyor motor, located in an industrial facility where there is supervision and written saftey procedures, must have a disconnect within sight of the motor.
B: Motor disconnects for motors located in an area where it would be dangerous to operate the disconnect switch must be within sight of the motor.
C: An exhaust fan motor located on the roof of a commercial building must have a disconnect located within sight of the motor.
D: A motor controller disconnect cannot serve as the disconnect for the motor.

Question 88: 430.107 Readily Accessible.

Question ID#: 10613.0

These disconnects for the overhead door motors are mounted in the control panel at floor level, are within sight of the motors, and are readily accessible.

There are no exceptions to the requirement that at least one of the disconnects for a motor be readily accessible.

Being readily accessible is defined in Article 100 as follows: ***"Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, and so forth."***

A disconnect for rooftop HVAC equipment that is mounted on the equipment itself, or is adjacent to the equipment, is permitted even though access to the rooftop itself requires use of a ladder.

Question 88: Which of the following is a true statement about motor disconnects?

A: Motor disconnects must be mounted within 10 ft. of the motor.
B: Motor disconnects must be mounted on the equipment that is powered by the motor.
C: Motor disconnects must be mounted on the same level as the motor.
D: The branch circuit overcurrent device, the motor controller disconnect, or the motor disconnect must be readily

accessible.

Question 89: 430.109 Type.

Question ID#: 10614.0

Disconnecting means shall be a type listed in Section 430.109(A -G).

Many different types of disconnects are permitted. Regardless of the type used, horse power (HP) rated disconnects are required to be rated for no less than the HP of the motor they are disconnecting.

General rules permit the following types of listed equipment to be used as motor disconnects:

- A HP rated motor circuit switch
- A molded case circuit breaker
- A molded case switch
- A combination motor controller incorporating an instantaneous trip circuit breaker
- A self protected combination motor controller
- A listed manual motor controller that is marked, ***Suitable as Motor Disconnect***

- System Isolation Equipment consisting of a motor circuit switch, a molded case circuit breaker, or a molded case switch

Disconnects permitted for Special Situations:

- For motors of 1/8th HP or less: the branch circuit fuse or circuit breaker.
- For non-movable motors rated 2 HP or less: a general use snap switch with twice the amperage of the motor's full load current (FLC), for AC motors: a general use AC rated switch rated for at least 125% of the motor's FLC, or a manual motor controller listed and rated for not less than the motor and marked suitable as a motor disconnect.
- For motors rated over 2-HP thru 100-HP with auto-transformer controllers: a general use snap switch under conditions specified in 430.109.
- Isolation switches for stationary motors rated more than 40-HP DC or more than 100-HP AC: a general use snap switch if marked "Do Not Operate Under Load."
- For cord-and-plug-connected motors: A plug and receptacle rated for not less than the motor's rating. Note: A HP rated plug and receptacle are not required for listed cord an plug connected appliances in accordance with 422.33, room air-conditioners in accordance with 440.63, or portable motors rated 1/3rd HP or less.
- For Torque motors a general use snap switch.

Question 89: A one horsepower motor disconnecting means shall not be:

A: Rated more than 1 horsepower.
B: Rated less than 1 horsepower.
C: Cord and plug connected.
D: A molded case circuit breaker.

Question 90: 430.122 Conductors - Minimum Size and Ampacity.

Question ID#: 10615.0

The minimum ampacity of conductors supplying power conversion equipment is 125% of its rated input.

Branch circuit and feeder conductors supplying power conversion equipment included as part of an adjustable-speed drive system are required to have a rating equal to at least 125% of the power conversion equipment's power input.

For example, if the input for a power conversion system that included an adjustable-speed drive was 50 amps, the minimum ampacity for a feeder supplying the equipment is 62.5 amps (50 amps X 1.25 = 62.5 amps).

If the adjustable speed drive system incorporates a by-pass device, the ampacity of the supply conductors is required to be the larger of the following:

(1) 125% of the rated input of the power conversion equipment itself, or (2) 125% of the motor FLC based on the motor full load current tables in Article 430.

Question 90: What is the required ampacity of the supply conductors for an adjustable speed drive system with a rated input of 75 amps?

A: 75 amps.
B: 82.5 amps.
C: 86.25 amps.
D: 93.75 amps.

Generators.

Question 91: 445.13 Ampacity of Conductors.

Question ID#: 10617.0

The minimum ampacity of conductors between a generator and the first disconnect is 115% of its rated output.

The ampacity of the conductors between a generator and the first fuse or circuit breaker cannot be less than 115% of the rating on the generator nameplate. A conductor used as a neutral is permitted to be sized in accordance with section 220.61.

For example, if the nameplate rating of the generator is 12 kW at 240 volts AC, its maximum current output is 50 amps (12,000 Ã· 240 volts = 50 amps). The minimum size of the ungrounded conductors between the generator and its first overcurrent device is 57.5 amps (50 amps X 1.15 = 57.5 amps).

Grounding and bonding conductors that will carry ground fault current for AC generators are required to be at least as large as are required by 250.30(A), which requires the grounding electrode and system bonding jumper to be selected from Table 250.66.

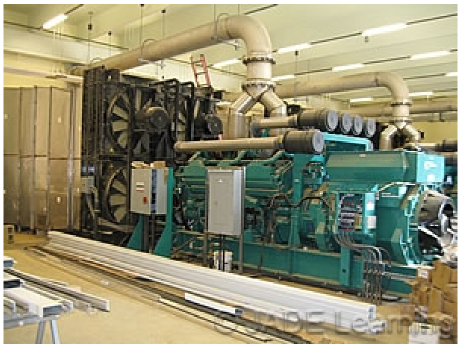
For example, if the largest ungrounded conductors from a generator to the first overcurrent device are No. 2 AWG or smaller the minimum size permitted from Table 250.66 for grounding and bonding conductors is a No. 8 CU .

Question 91: The generator nameplate reads 100 amperes. What is the minimum circuit ampacity of the conductors from the generator terminals to the first overcurrent device?

A: 100 amperes.
B: 115 amperes.
C: 125 amperes.
D: 150 amperes.

Question 92: 445.18 Disconnecting Means Required for Generators.

Question ID#: 10618.0



Generators are required to be equipped with a disconnecting means.

Generators shall be equipped with a disconnect that can be locked in the open position. The disconnecting means is required to completely disconnect all equipment on the generator from the feeders and branch circuits that the generator supplies.

There are two conditions when generators are not required to have a disconnect:

(1) Portable generators which are cord-and-plug connected do not require a disconnecting means.

(2) If (a) the driving means can be easily shut down, cannot restart on its own, and is lockable in the off position, and (b) the generator is not operated in parallel with another source of power or in parallel with another generator a disconnecting means is not required.

Question 92: Which of the following statements about the disconnecting means for a generator is FALSE?

A: A generator disconnect must be capable of being locked in the open position.
B: The disconnecting means must disconnect the generator feeder conductors.
C: All types of generators are required to have a disconnecting means.
D: Cord and plug connected portable generators do not require an additional disconnecting means.

Transformers.

Question 93: 450.1 Scope.

Question ID#: 10620.0

Article 450 covers all types of transformers, except those listed as exceptions in section 450.1

Article 450 covers the installation of all types of transformers except those included in the eight exceptions listed in section 450.1, Scope. Transformers not covered in Article 450 are:

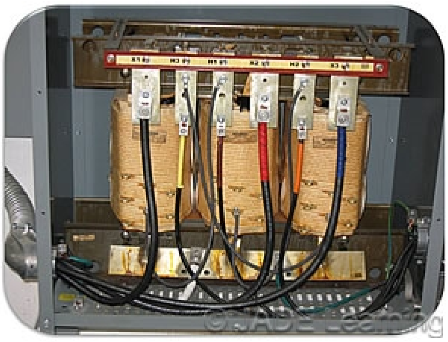
- Current transformers which are commonly used in metering and instrumentation.
- Dry-type transformers incorporated within listed equipment.
- Transformers for listed X-ray equipment, high-frequency, or electrostatic-coating equipment.
- Transformers listed for use with Class 2 and Class 3 circuits installed in accordance with article 725.
- Transformers listed for use with sign and outline lighting installed in accordance with Article 600.
- Transformers listed for use with electric-discharge lighting installed in accordance with Article 410.
- Transformers listed for use with power-limited fire alarm circuits installed in accordance with Part III of Article 760.
- Transformers used for testing, research, or development, provided effective arrangements are made to prevent persons from contacting live parts.

Question 93: Which types of transformers are not covered in Article 450?

A: Auto-transformers.
B: Transformers rated over 600 volts.
C: Transformers rated 600 volts and less.
D: Current transformers used for instrumentation.

Question 94: Table 450.3(B) Maximum Rating of Overcurrent Protection for Transformers 1000 Volts and Less.

Question ID#: 10621.0



Overcurrent protection for transformers is specified in tables 450.3(A&B).

Of the transformers shown in Table 450.3(B), the most common types of transformers found in commercial and industrial buildings have a secondary current of 9 amps or more and have overcurrent protection for conductors supplying the transformer. If the transformer's primary overcurrent protection has a rating no greater than 125% of the current rating of the transformer, then secondary protection for the transformer is not required. Note, where 125% does not correspond with a standard size fuse or breaker, it shall be permissible to round up to the next standard size.

If the secondary side of the transformer does not have overcurrent protection, then the conductors from the transformer secondary are considered transformer secondary conductors," and are selected from 240.21(C). If the transformer secondary conductors are not over 10 ft. long, they must be big enough to supply the combined calculated load on the circuits supplied by the secondary conductors. The transformer secondary conductors also cannot be less than the rating of the overcurrent protective device at the termination of the secondary conductors.

For example, a 3-phase, 75 KVA transformer with a 480 volt primary and 208 volt secondary.

Primary:
75,000 VA Ã· 830V (480 x 1.73) = 90 amps.
90 amps x 1.25 = 112.5 amps.
Next standard size fuse = 125 amps.

Secondary:
75,000 VA Ã· 360V (208 x 1.73) = 208 amps.
Calculated load on secondary circuits = 180 amps.
Overcurrent device at termination of transformer secondary conductors = 200 amps
Size of transformer secondary tap conductors = 3/0 cu.

Question 94: What is the maximum size fuse on the primary of a 3-phase, 112 KVA transformer, 480 volt primary, 240 volt secondary if there is no secondary overcurrent protection?

A: 125 amps.
B: 135 amps.
C: 150 amps.
D: 175 amps.

Question 95: 450.13(A)&(B) Accessibility Open and Hollow Space Installations.

Question ID#: 10622.0

Dry transformers rated 600 volts or less and not exceeding 50 KVA are permitted to be installed above suspended ceilings.

All transformers and transformer vaults are required to be readily accessible to personnel qualified to perform maintenance and inspections. However, there are two types of installations where ready access is not required.

Regardless of their KVA rating, 450.13(A) does not require ready access to dry type transformers rated 600 volts or less if they are mounted in the open on a wall, column, or other structure. For example, a dry transformer rated 1000 volts or less is permitted to be mounted high on the wall of a high-bay facility even if a ladder, scaffolding, or scissor-lift were required to gain access to it.

Section 450.13(B) permits 50 kVA and smaller dry-type transformers rated 1000 volts or less to be installed in accessible hollow spaces of buildings if they are separated from combustible materials and adequately ventilated as required by section 450.9. For example, a transformer operated at 1000 volts or less and rated 50 KVA or less can be installed above a dropped lay-in ceiling if the area is accessible, ventilated and fire resistant.

Regardless of the transformer's rating or where it is installed, dry type transformers are not permitted to be mounted so that the vents are flush against a wall or other structure that might interfere with air flow around the transformer coils.

Section 450.14 Disconnecting Means requires a transformer, other than Class 2 or Class 3 transformers, to have a disconnecting means located in sight of the transformer or in a remote location. If the disconnecting means is remote from the transformer, the disconnecting means must be lockable and the location of the disconnecting means must be field marked on the transformer.

Question 95: Which of the following installations is permitted for transformers mounted inside a building?

A: A dry type transformer with a primary rating of 480 volts and a secondary rating of 208 volts mounted in the open 12 ft. off the floor.
B: A dry type transformer rated less than 1000 volts installed next to combustible material.
C: A liquid cooled transformer that is not readily accessible.
D: A dry type transformer that is mounted in such a way as to block the transformer cooling vents.

Temporary Wiring.

Question 96: 590.3 & 4 (D) Time Constraints and General.

Question ID#: 10624.0

Temporary wiring used during construction is permitted to remain in place until the construction is finished.

Unless modified by Article 590, the installation of temporary wiring is required to comply with the NEC requirements for permanent wiring.

The time restrictions for temporary installations vary depending on the purpose of the temporary installation:

- There is no time limit when temporary wiring is used for construction, repair, maintenance, or demolition of buildings or other structures.
- Festival and holiday decorative lighting is permitted for a maximum of 90 days.
- Temporary wiring used during emergencies, testing, experiments, and development is permitted; and, no time limit is specified.
- Temporary wiring is required to be removed when its purpose for being installed is completed.

Only grounding type receptacles are permitted for temporary wiring installations. Unless they are installed in a continuous metal cable or raceway that is recognized by 250.118 as an equipment grounding conductor, all branch circuits for temporary wiring are required to include an equipment grounding conductor that is electrically connected to all receptacles.

Receptacles are not permitted to be supplied by ungrounded conductors in circuits that also supply temporary lighting. Requiring separate circuits for receptacles and lighting is a safety issue. It prevents injuries that could occur from the loss of lighting if an overcurrent protective device for a circuit that supplied both receptacles and lighting were tripped.

Question 96: Which of the following statements about temporary wiring is true?

A: Temporary wiring methods like flexible cords and cables can take the place of permanent wiring.
B: Two wire receptacles can be used for temporary wiring if a 3-wire adapter is supplied for cord plugs.
C: Receptacles used for temporary wiring must be of the grounding type.
D: Wiring used for temporary lighting and receptacles can be on the same circuit.

Question 97: 590.6 GFCI Protection for Personnel.

Question ID#: 10625.0

GFCI protection is required for 125 volt, 15, 20, and 30 amp receptacles installed for temporary wiring.

Ground Fault Circuit Interrupter (GFCI) protection is required for all 125 volt, 15, 20, and 30 amp receptacles used by personnel that are installed for temporary wiring. GFCI protection is also required for receptacles that are part of the permanent wiring if the permanent receptacles are used by personnel during construction, maintenance or repair.

The requirements for GFCI protection apply to receptacles used for temporary wiring regardless of the source of power. Receptacles supplied by an on-site generator as well as those supplied by a utility company must have GFCI protection.

The required GFCI protection is permitted to be supplied by GFCI circuit breakers, GFCI receptacles, or by GFCI listed cord sets identified to provide portable protection for personnel.

Receptacles in industrial establishments that supply equipment that would be more of a hazard if power was lost or that would not operate with GFCI protection are not required to be GFCI protected. This exception is permitted only where maintenance and supervision practices guarantee that qualified personnel work in accordance with an assured grounding program.

A written assured equipment grounding program that is continuously enforced, can be used instead of providing GFCI protection for receptacles rated other than 125 volts, 15, 20, and 30 amps.   Because of the paperwork required, this is not a popular option.

Question 97:   Which of the following installations or activities require GFCI protection for personnel?

A: A circuit used for temporary lighting.
B: A feeder to a construction trailer.
C: A receptacle outlet for an electric drill used during maintenance operations.
D: A receptacle outlet used for a pressure tester in a quality control lab.

Industrial Machinery.

Question 98:   670.3 Machine Nameplate Data.

Question ID#: 10627.0

Section 670.3 lists data required to be marked on the nameplate of industrial machinery.

The following data is required to be marked on the nameplate of industrial machines:

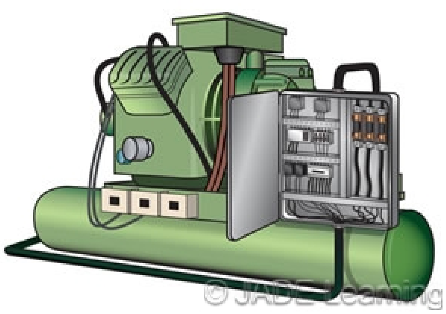
- The voltage, frequency, full load current (FLC), and number of phases supplied to the machine.
- Note: If more than one circuit supplies the machine, the nameplate is required to include voltage, frequency, full load current (FLC), and number of phases for each supply circuit.
- The FLC on the nameplate is to include the total of FLC of all motors and/or other equipment operated simultaneously.
- The rating of the maximum short-circuit and ground-fault protective device
- The FLC of the largest motor.
- The industrial control panel's short-circuit current rating based on either the control panel's listing or on a method approved by the Authority Having Jurisdiction.
- Electrical diagram number(s) or the number of the index to the electrical drawings.

Question 98:   Industrial machinery nameplates shall provide all of the following information except:

A: Supply voltage.
B: Full load current.
C: Ampere rating of largest motor.
D: Ampere rating of smallest motor.

Question 99: 670.4(B) & (C) Disconnecting Means and Overcurrent Protection.

Question ID#: 10628.0



Overcurrent protection for industrial machinery is permitted to be installed either ahead of the machine or to be incorporated within the control panel.

Industrial machines are required to include a means for disconnecting the machine. The disconnect is permitted, but not required, to provide overcurrent protection.

Overcurrent protection for an industrial machine can be provided as part of the machine or as a separate disconnect installed ahead of the machine's disconnect. In either case, if more than a single circuit supplies the machine, all sources of power require a disconnect and overcurrent protection.

Question 99: Which of the following is a true statement about industrial machines?

A: Overcurrent protection is required to be part of the disconnecting means.
B: If the disconnect is mounted remotely from the machine, a plaque must be mounted on the machine describing the location of the disconnect.
C: The overcurrent protection for an industrial machine must be installed at the machine.
D: Overcurrent protection for an industrial machine may be mounted ahead of the machine's disconnecting means.

Question 100: 670.4(A) Supply Conductors and Overcurrent Protection. Size.

Question ID#: 10629.0

The feeder for this industrial machine panel is based on the calculated load for all the motors and other loads.

The requirements for sizing feeders and branch circuit conductors supplying an industrial machine are similar to the requirements in article 430 for supplying a group of motors and other loads.

The ampacity of conductors supplying an industrial machine must be equal to the total of the following values:

125% of the full load current (FLC) of the largest motor, plus:

the sum of the FLC of all other motors that are operated simultaneously, plus:

125% of any resistance heating loads that are operated simultaneously.

For example, if an industrial machine had two motors rated 5 amps and 10 amps and a heating load rated 20 amps, the feeder to the machine would be selected to carry a minimum load of 42.5 amps (5 amps + 12.5 amps + 25 amps). The largest motor and the heating load are taken at 125% of the connected load. For the largest motor, 10 amps x 1.25 = 12.5 amps. For the heating load, 20 amps x 1.25 = 25 amps.

Question 100: An industrial machine has a single motor rated for 8 amps and a resistance heating load of 40 amps. What is the minimum ampacity of the feeder supply conductors for the machine?

A: 48 amps.
B: 50 amps.
C: 60 amps.
D: 80 amps.

Answer Sheet

Darken the correct answer. Sample: A ● C D

AK Commercial & Industrial Wiring (2014 NEC) Course# 15190 8 Industry Related Credit Hours $90.00

1.) A B C D	**21.) A B C D**	**41.) A B C D**	**61.) A B C D**	**81.) A B C D**
2.) A B C D	**22.) A B C D**	**42.) A B C D**	**62.) A B C D**	**82.) A B C D**
3.) A B C D	**23.) A B C D**	**43.) A B C D**	**63.) A B C D**	**83.) A B C D**
4.) A B C D	**24.) A B C D**	**44.) A B C D**	**64.) A B C D**	**84.) A B C D**
5.) A B C D	**25.) A B C D**	**45.) A B C D**	**65.) A B C D**	**85.) A B C D**
6.) A B C D	**26.) A B C D**	**46.) A B C D**	**66.) A B C D**	**86.) A B C D**
7.) A B C D	**27.) A B C D**	**47.) A B C D**	**67.) A B C D**	**87.) A B C D**
8.) A B C D	**28.) A B C D**	**48.) A B C D**	**68.) A B C D**	**88.) A B C D**
9.) A B C D	**29.) A B C D**	**49.) A B C D**	**69.) A B C D**	**89.) A B C D**
10.) A B C D	**30.) A B C D**	**50.) A B C D**	**70.) A B C D**	**90.) A B C D**
11.) A B C D	**31.) A B C D**	**51.) A B C D**	**71.) A B C D**	**91.) A B C D**
12.) A B C D	**32.) A B C D**	**52.) A B C D**	**72.) A B C D**	**92.) A B C D**
13.) A B C D	**33.) A B C D**	**53.) A B C D**	**73.) A B C D**	**93.) A B C D**
14.) A B C D	**34.) A B C D**	**54.) A B C D**	**74.) A B C D**	**94.) A B C D**
15.) A B C D	**35.) A B C D**	**55.) A B C D**	**75.) A B C D**	**95.) A B C D**
16.) A B C D	**36.) A B C D**	**56.) A B C D**	**76.) A B C D**	**96.) A B C D**
17.) A B C D	**37.) A B C D**	**57.) A B C D**	**77.) A B C D**	**97.) A B C D**
18.) A B C D	**38.) A B C D**	**58.) A B C D**	**78.) A B C D**	**98.) A B C D**
19.) A B C D	**39.) A B C D**	**59.) A B C D**	**79.) A B C D**	**99.) A B C D**
20.) A B C D	**40.) A B C D**	**60.) A B C D**	**80.) A B C D**	**100.) A B C D**

Email answer sheet to: registrar@jadelearning.com

Please fill out the following information and mail this answer sheet along with payment to:
JADE Learning 225 E Robinson St #570, Orlando, FL 32801
Phone: 1 (800) 443-5233
This course is $90.00
We accept: checks, cash, money orders, credit or debit cards. Visa, MasterCard, AMEX or Discover.

Name ____ AK License #_________________________

Mailing Address ____ Phone _____________________

City, State, Zip Code _______________________________________ CC Code _________________

Credit Card Number ____ Expiration Date ______________

Email Address ____