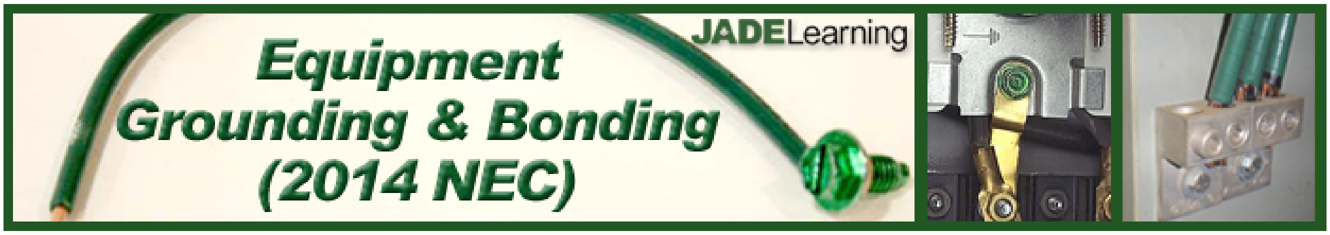


Equipment Grounding & Bonding (2014 NEC) (Homestudy)

Oregon Electrical License

Equipment grounding and bonding is done after the first overcurrent device in the electrical distribution system. Equipment grounding and bonding conductors are installed to connect normally non-current-carrying metal parts of equipment together and to the system grounded conductor and the grounding electrode. Equipment grounding and bonding conductors create the ground-fault current path that will return fault current to the source, enabling the overcurrent device to de-energize the circuit.

Course# 104 4 Code Related Credit Hours $55.00

This course is currently approved by the Oregon Building Codes Division under course number 104.

Completion of this continuing education course will satisfy 4.000 credit hours of course credit type 'Code Related' for Electrical license renewal in the state of Oregon. Course credit type 'Code Related'. Board issued approval date: 7/24/2014. Board issued expiration date: 10/1/2017. .

JADE Learning's sponsor number from the Oregon Building Codes Division is #707.

Equipment Grounding & Bonding (2014 NEC) (Homestudy) - OR

Part I General

Question 1: Article 100. Bonding Jumper, Equipment.

Question ID#: 11036.0

The ground-fault path between these two metal racks is ensured with a bonding jumper.

The main purpose of equipment bonding jumpers is to ensure that the electrical continuity of an effective ground-fault current path is not interrupted.

Section 250.96(A) requires metal raceways and metal enclosures that are to serve as equipment grounding conductors to be bonded together so that they can safely conduct any fault current that is likely to be imposed on them.

For example, in many cases, metal raceways that enter an open bottom switchboard will not be physically connected to the metal enclosure. The installation of an equipment bonding jumper joining the raceway to the enclosure ensures electrical continuity between the raceway and the switchboard in case a ground-fault occurs.

Question 1: Which of the following is described as the connection between two or more portions of the equipment grounding conductor?

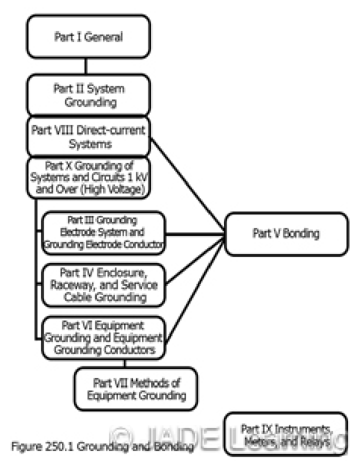
A: An equipment bonding jumper.
B: A main bonding jumper.
C: A system bonding jumper.
D: A grounding electrode conductor.

Question 2: 250.1 Scope.

Question ID#: 11037.0

Article 250 covers the general requirements for the bonding and grounding of different types of electrical installations and subdivides these requirements into six separate groups:

- The systems, equipment, and circuits that are permitted, required, not required, or not permitted to be grounded.
- The circuit conductor to be grounded on grounded systems.
- The location of grounding connections.
- The types and sizes of bonding and grounding conductors and electrodes.
- The methods of grounding and bonding.
- The conditions under which guards, insulation, isolation, or guards may be substituted for grounding.



Article 250 covers the general requirements for the bonding and grounding of different types of electrical installations and subdivides these requirements into six separate groups.

Figure 250.1 illustrates how Article 250 is organized. There are ten different Parts in Article 250, I-X. This course will focus on:

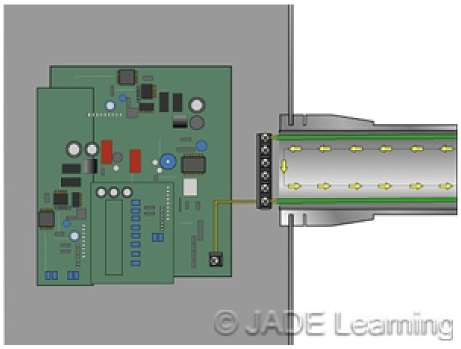
- Part I General
- Part V Bonding
- Part VI Equipment Grounding and Equipment Grounding Conductors
- Part VII Methods of Equipment Grounding

Question 2: In which part of Article 250 is Table 250.122, Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment, located?

A: Part I.
B: Part V.
C: Part VI.
D: Part VII.

Question 3: 250.6 Objectionable Current.

Question ID#: 11038.0



Low amperage current can develop across poor connections in lengthy sections of metallic raceways. This objectionable current, while low, can cause problems for sensitive instruments and circuits.

Objectionable current is neutral current circulating on equipment grounding conductors. Objectionable current is caused by improper grounding of the grounded conductor after the service.

The NEC requires that the grounded conductor be connected to a grounding electrode at the service or at a separately derived system, and nowhere else. When done correctly, normal neutral current flowing on the grounded conductor stays on the grounded conductor and does not flow on equipment grounding conductors. If the grounded conductor is connected to an equipment grounding conductor, or bonded to equipment enclosures, then normal grounded neutral current will travel on raceways, cable armor or other types of equipment grounding conductors. This can cause a number of problems, including low frequency interference with sensitive electronic equipment.

Section 250.6 includes 4 ways to prevent objectionable current:

- Discontinue one or more of the grounding connections.
- Move the location of the grounding connection.
- Open the ground path causing the objectionable current.
- Take other suitable actions.

Question 3: If multiple grounding connections cause objectionable current, which of the following actions is NOT permitted as a means of stopping objectionable current?

A: Interrupting one or more (but not all) grounding connections to the equipment.
B: Changing the locations where the grounding connections are made.
C: Disconnecting the electronic equipment, its raceways, and its enclosure from the electrical system equipment ground and connecting it to a separate earth ground.
D: Interrupting the continuity of the conductor or conductive path causing the objectionable current.

Question 4: 250.8(B) Connection of Grounding and Bonding Equipment. Methods Not Permitted.

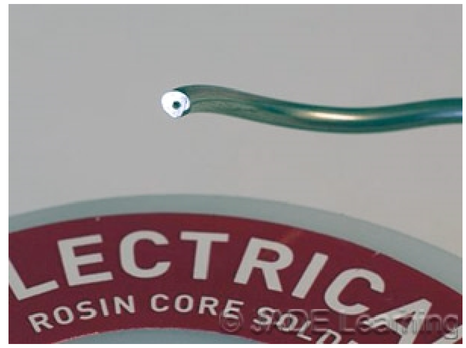
Question ID#: 11039.0

Connections that depend solely upon solder cannot be used for grounding connections.

The reason solder is not permitted is that when equipment grounding conductors carry fault-current, they can get very hot. High temperatures can exceed the melting point of the solder and weaken or destroy the connection. This could create a shock hazard to those who come in contact with the equipment.

Soldering a connection is not prohibited, but it cannot be the only method used to connect grounding and bonding conductors

In the case of a phase-to-ground fault, the most important connection that must remain intact is the grounding connection. If the grounding connection were to fail, then the normally non-current-carrying metal parts of equipment, appliances, electrical enclosures and the like may become energized. During a ground fault, the equipment grounding conductor works as the path for fault current to return to the source in order to trip the overcurrent device.



The melting range of solder can be as low as 90 degrees Celsius. The heat from fault current can be well above this level creating a shock hazard as it melts.

Question 4: Which of the following connections is prohibited as the only way to make a grounding connection?

A: Pressure connectors.
B: Solder.
C: Terminal bars.
D: Exothermic welding.

Question 5: 250.10 Protection of Ground Clamps and Fittings.

Question ID#: 11040.0

Equipment in damp earth will be subject to corrosion. To maintain grounding and bonding integrity, you will need clamps listed to prevent any damage from corrosion.

Clamps of all types are required to be used according to their listing. Ground clamps and/or other grounding and bonding fittings are listed for general use when installed where they are not likely to be damaged. If installed in a location where damage is likely, they are required to be protected by metal, wood, or an equivalent protective covering.

Clamps listed for connecting a grounding electrode connector to a ground rod are designed to be buried when connected to the rod; these clamps are made of bronze and they are designed and listed to retain their structural integrity when directly buried in the earth. Section 250.53(G) requires the upper end of the rod or pipe to be flush with or below ground level which means the clamp will be in direct contact with the earth where it is subject to corrosion.

Pipe clamps which are listed for connecting grounding and bonding conductors to metal pipes and are not listed for direct burial should not be used to connect grounding electrode conductors to driven or buried ground rods or pipes.

In older installations, it was common to see pipe clamps used to connect grounding electrode conductors to driven ground rods. If the clamps had been in place for a number of years, usually the pipe clamp was no longer secured to the rod because the steel screws used to secure the clamp to the rod were rusted away. A loose clamp obviously impairs the connection between the grounding electrode conductor and the grounding electrode.

Question 5: Ground clamps and/or other fittings used for connecting a grounding electrode conductor to a grounding electrode are approved for general use:

A: Without protection in all locations when subject to physical damage.
B: When installed without protection when not subject to physical damage.
C: Only when protected by a metal enclosure when subject to physical damage.
D: Only when protected by a wood enclosure when subject to physical damage.

Question 6: 250.32(A) Buildings or Structures Supplied by a Feeder or Branch Circuit. Grounding Electrode.

Question ID#: 11041.0

Where a building or structure is supplied by a feeder or branch circuit, a grounding electrode system must be established at each building. The equipment grounding bar in the disconnect enclosure at the second building must be bonded to the grounding electrode system in accordance with 250.32(B) or (C).

A grounding electrode is always required at the second building unless the building is supplied by a single branch circuit, (including a multiwire branch circuit). The single branch circuit must include an equipment grounding conductor (EGC) that will be used for grounding the normally non-current-carrying metal parts of equipment.

A grounding electrode is required at the second building in order to limit the voltage to ground if the electrical system in the second building is hit by lightning, if there is a line surge, or if there is unintentional contact with higher-voltage lines.

The first 5 feet of metal water pipe above ground is permitted to extend the connection to the grounding electrode (water pipe).

Question 6: Which of the following installations require a grounding electrode to be installed at the second building?

A: When the second building is supplied by a single multiwire branch circuit with an equipment grounding conductor.
B: When a grounding electrode already exists at the second building.
C: When the feeder to the second building does not have an equipment grounding conductor.
D: When the second building is supplied by feeders or branch circuits.

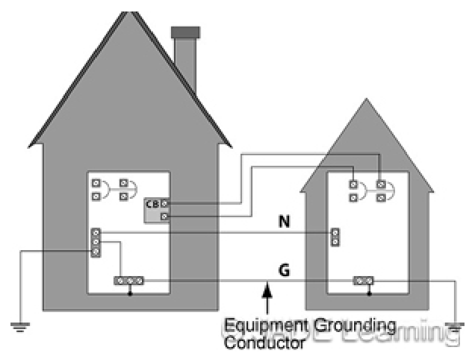
Question 7: 250.32(B)(1) Buildings or Structures Supplied by a Feeder or Branch Circuit. Grounded Systems.

Question ID#: 11042.0

Section 250.32(B) requires that an equipment grounding conductor is installed with feeders and branch circuits that supply buildings or structures.

The equipment grounding conductor installed with the feeder must be connected to the building or structure and to the grounding electrode. The equipment grounding conductor is used for grounding and bonding equipment in the second building.

The equipment grounding conductor run with the feeder is not connected to the grounded neutral conductor at the second building. There are two reasons to keep the equipment grounding conductor separate from the grounded neutral conductor at the second building: (1) If there is a fault at the second building, fault current should travel on the equipment grounding conductor, not on both the grounded neutral conductor and the equipment grounding conductor. (2) Normal current on the grounded neutral conductor should not travel on the equipment grounding conductor.



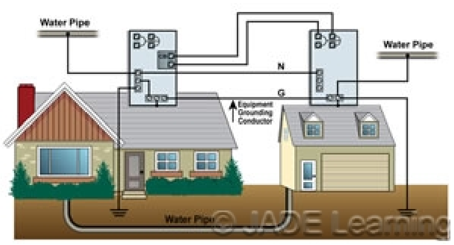
The equipment grounding conductor run with the feeder is not connected to the grounded neutral conductor at the second building.

Question 7: Which of the following statements about an equipment grounding conductor run with a feeder that supplies a second building is true?

A: The equipment grounding conductor is connected to the metal enclosure of the building disconnecting means and to the grounding electrode.
B: The equipment grounding conductor is connected to the grounded neutral conductor inside the disconnect at the second building.
C: The equipment grounding conductor is not connected to the grounding electrode at the second building.
D: The equipment grounding conductor is isolated from the building disconnecting means.

Question 8: 250.32(B)(1) Exception No. 1. Buildings or Structures Supplied by a Feeder or Branch Circuit.

Question ID#: 11043.0



In new construction, a feeder or branch circuit that supplies a building is required to include an equipment grounding conductor.

In earlier editions of the National Electrical Code, an equipment grounding conductor was not required to be run with a feeder to a second building. The grounded neutral conductor was bonded to the building disconnecting means and was used to ground equipment in the second building. There are still many installations like this.

Exception No. 1 to 250.32(B)(1) takes this situation into account and permits the grounded neutral conductor to carry fault current back to the service at the main building if there is not an equipment grounding conductor installed with the feeder.

In order for the exception to apply, the supply to the building cannot contain an equipment grounding conductor, there can be no parallel metallic paths between the two buildings, and there cannot be ground fault protection of equipment installed ahead of the feeder.

Question 8: Which of the following is a condition that would allow the grounded neutral conductor to be used to ground equipment and enclosures in a second building supplied by a feeder?

A: A grounding electrode conductor is installed at the second building.
B: An equipment grounding conductor is not run with the feeder.
C: Ground-fault protection for equipment is installed at the service.
D: The wiring method for the feeder is UF cable 6/3 with ground.

Part V Bonding

Question 9: 250.96 Bonding Other Enclosures.

Question ID#: 11045.0

The continuity of equipment grounding is maintained from this raceway to cable tray.

Raceways, cable armor, cable tray, frames, and fittings that are used as equipment grounding conductors are required to be bonded where bonding is necessary to ensure electrical continuity and the capacity to carry fault current.

Paint, corrosion, and nonconductive surface coatings that may impair the electrical conductivity are required to be removed from raceways, cable armor, enclosures, and other material used for grounding and bonding unless conductivity is ensured by fittings designed to make such removal unnecessary.

If the design and listing of the material used for grounding ensures the continuity of equipment grounding, no additional bonding method is required.

Raceways containing isolated grounding circuits are permitted to be isolated from the enclosures that the raceway is supplying with listed nonmetallic raceway fittings, located at the point of attachment to the enclosure, provided metal enclosures are grounded with an internal insulated equipment grounding conductor.

Question 9: When are metal raceways and enclosures required to be bonded together?

A: Only when the raceway contains an isolated grounding circuit.
B: Where necessary to ensure electrical continuity when the raceway is used as the equipment grounding conductor.
C: Only when the raceway is installed without a supplementary equipment grounding conductor.
D: Only when the raceway is installed with a supplementary equipment grounding conductor.

Question 10: 250.97 Bonding for Over 250 Volts.

Question ID#: 11046.0

Raceway and cable connections made through pre-punched concentric and eccentric knockouts are considered to be impaired connections that may not effectively carry fault current in the event of a ground fault.

For circuits greater than 250 volts to ground, when connecting metal raceways to enclosures through concentric or eccentric knockouts that are not listed to provide a reliable bonding connection, the NEC requires the use of bonding-type locknuts, bonding bushings, and bonding jumpers to ensure raceways are effectively bonded to enclosures.

Raceways and cable armor for circuits exceeding 250 volts to ground that are connected to enclosures through knockouts that are not oversized, concentric, or eccentric, are permitted to be bonded to the enclosure by any of the following means:

- Threadless connectors and couplings for cables having a metallic sheath.
- Double locknut connections (one locknut inside and one outside of enclosures) for RMC & IMC conduit.
- EMT, FMC, and Cable connectors that seat firmly against the box or cabinet, with one locknut on the inside of boxes, enclosures, and cabinets.
- Other listed fittings such as threaded hubs that are listed for grounding.

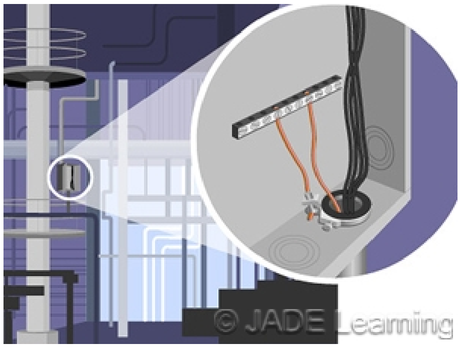
Pre-punched knockouts are considered impaired connections and will require bonding bushings or jumpers to maintain fault-current path.

Question 10: If an RMC raceway containing a 277/480 volt branch circuit is connected to a panelboard, which of the following connections does NOT require the use of bonding-bushings or other means to ensure the raceway is bonded to the enclosure?

A: RMC connected through an eccentric knockout that is not listed to provide a reliable bonding connection.
B: RMC connected with double locknut construction through a correctly sized hole made with a knockout punch.
C: IMC connected through an eccentric knockout that is not listed to provide a reliable bonding connection.
D: RMC connected to an oversized knockout with reducing washers.

Question 11: 250.100 Bonding in Hazardous (Classified) Locations.

Question ID#: 11047.0



Continuity is especially important in hazardous locations where any spark could ignite an explosion.

Bonding is essential for electrical safety in hazardous locations as defined in sections 500.5, 505.5, and 506.5. During a ground-fault, when there are substantial currents flowing through metal conduits or raceways, every loose connection point in the raceway system could be a potential source of sparks and ignition.

Bonding of raceways by one of the methods specified in 250.92(B)(2) thru 250.92(B)(4), which establishes an effective path for fault current, helps to minimize resistance for ground-fault current to flow back to the source in order to facilitate the operation of the overcurrent protection device. This raceway bonding is required even if the raceway in question contains a separate wire type equipment grounding conductor.

It is important to understand that this requirement for raceway bonding in hazardous locations does not depend on the voltage of the circuit in the raceway. Empty raceways for future use, as well as raceways containing low voltage wiring for signal and communication circuits, are all required to be bonded together to establish a low resistance path for fault current.

Question 11: Why are raceways in hazardous locations bonded together?

A: To establish a connection to a grounding electrode.
B: To establish a connection to earth.
C: To establish a connection to a grounding electrode conductor.
D: To establish a connection that will provide electrical continuity and conductivity.

Question 12: 250.102(E) Bonding Conductors and Jumpers. Installation.

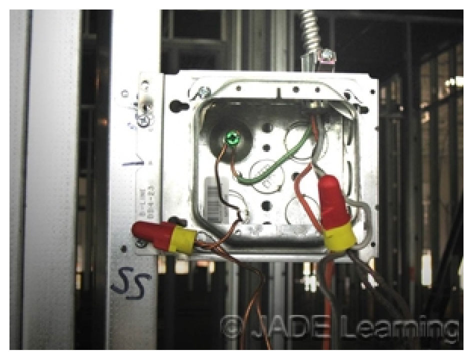
Question ID#: 11048.0

An equipment bonding jumper is defined in Article 100 as the connection between two or more portions of the equipment grounding conductor.

The equipment bonding jumper is permitted to be installed either inside or outside of a raceway or enclosure. When the jumper is installed on the outside, the length is limited to not more than 6 feet. The bonding jumper is required to be routed with the raceway.

It is important to keep the length of an external bonding jumper as short as possible in order to limit the resistance of the bonding jumper.

However, an uninterrupted length of wire used as an equipment bonding jumper and installed in one length inside a raceway will have less impedance than an external equipment grounding conductor used with additional bonding fittings on the outside of the conduit.



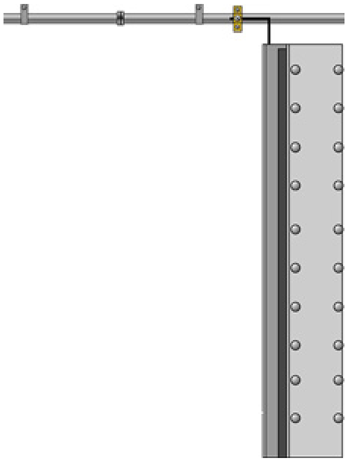
A common way to effectively bond different metallic surfaces of enclosures, electrical equipment, pipes, tubes or structures together is with a copper conductor, rated lugs and appropriate bolts, fasteners or screws.

Question 12: What is the maximum allowable length for an equipment bonding jumper installed on the outside of a raceway?

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

Question 13: 250.104(A)(1) Bonding of Piping Systems and Exposed Structural Metal. Metal Water Piping.

Question ID#: 11049.0



The metal water piping in a building is usually bonded to the building steel.

Metal water piping system(s) installed in or attached to a building shall be bonded to the service equipment enclosure, the grounded conductor at the service, the grounding electrode conductor where of sufficient size, or to a grounding electrode.

The bonding of the metal piping system places the water piping at the same potential as other bonded conductive components and systems that are not normally intended to carry current. When a fault occurs and current is traveling on the water pipe or building steel, the shock hazard is greatly reduced if they are bonded together and both at the same potential. With different potentials on grounded objects, current can flow from one grounded object to another if a conductive path, such as through a person's body, is established. Metal water piping and exposed structural metal are bonded together so there is no potential difference between them, thereby reducing the chances of electric shock under fault conditions.

Question 13: Interior metal water piping systems installed in or attached to a building shall be bonded to any of the following EXCEPT:

A: The grounded conductor at a subpanel.
B: The service equipment enclosure.
C: The grounded conductor at the service.
D: The grounding electrode conductor.

Part VI Equipment Grounding and Equipment Grounding Conductors.

Question 14: 250.110 Equipment Fastened in Place (Fixed) or Connected by Permanent Wiring Methods.

Question ID#: 11051.0

This fixed bakery dough mixer has metal parts that could become energized and must be properly grounded.

Unless permitted by an exception(s), section 250.110 requires exposed normally non-current-carrying metal parts of fixed equipment, that are likely to become energized during an unintentional short-to-ground condition, to be grounded under any of the following conditions:

- The equipment or raceway is within 5 feet horizontally or 8 feet vertically of grounded objects and can be touched by people.
- The equipment or raceway is not isolated and is in a damp or wet location.
- The equipment or raceway is in electrical contact with metal.
- The equipment or raceway is in a hazardous location as covered by Articles 500 - 517.
- Except for metallic protective sleeves, the equipment or raceway is supplied by a wiring method that includes an equipment grounding conductor.
- If the equipment operates at voltage greater than 150 volts to ground.

There are 3 exceptions to the general rules that permit normally nonconductive metal equipment or raceways to be ungrounded. The exceptions include the following:

- Electrically heated appliances with a frame that is permanently and effectively insulated from ground like many clothes irons, coffee pots, waffle irons, and crock-pots.

- Distribution equipment enclosures such as transformer and capacitor cases that are mounted more than 8 feet above ground on wooden poles.
- Listed equipment that is distinctively marked as being double insulated, such as a 120 Volt hammer drill on a construction site.

In addition to these 3 exceptions, the general rules that require grounding are not applied to small metallic fasteners such as screws, rivets, nuts, and bolts, or nameplates on nonmetallic enclosures that are not likely to be energized.

Question 14: Which of the following is required to be grounded?

A: A listed 120 volt appliance that is marked as being double insulated.
B: A small metal nameplate secured by metal rivets to a nonmetallic enclosure.
C: The metal frame of a glass door that is operated by a 120 volt automatic door opener.
D: An electrical distribution transformer enclosure that is mounted 14 feet above grade on a wooden pole.

Question 15: 250.114 Equipment Connected by Cord and Plug.

Question ID#: 11052.0

Arc welders are a common example of cord-and-plug equipment that must be grounded.

Unless permitted by the exception, exposed, normally non-current-carrying metal parts of listed cord-and-plug-connected equipment are required to be connected to an equipment grounding conductor. An exception to the general requirement for grounding excludes handheld double insulated tools and double insulated small appliances like coffee machines, table lamps, and small double insulated electrical office machines.

The general requirements are divided into the following 4 sections:

- Hazardous locations covered in Articles 500 - 517.
- Equipment operated in excess of 150 volts to ground.
- Dwellings.
- Non-dwelling occupancies.

Regardless of the location, cord-and-plug-connected equipment that is required to be grounded includes equipment such as kitchen waste disposers, dishwashers, and window air conditioners that are fastened in place or that are mechanically attached to a structure. However, the grounding requirements also apply to some cord-and-plug-connected types of equipment that are not mechanically fastened in place but are also not portable such as refrigerators, freezers, washing machines, electric ranges, and clothes dryers.

Unless permitted by the exception for double insulated equipment, the grounding requirements also apply to smaller portable cord-and-plug appliances like microwaves, mixers, and bread machines, as well as hand-held tools.

Question 15: Unless permitted by the exception, which of the following types of cord-and-plug-connected equipment are normally required to have exposed, normally non-current-carrying metal parts grounded?

A: Table lamps.
B: Double insulated power tools.
C: Refrigerators.
D: Coffee makers.

Question 16: 250.118 Types of Equipment Grounding Conductors.

Question ID#: 11053.0

This conduit run maintains a conductive path connecting the non-current-carrying metal parts to the grounding electrode conductor.

An equipment grounding conductor is defined by the NEC as the conductive path installed to connect normally non-current-carrying metal parts of equipment together and to the system grounded conductor, or to the grounding electrode conductor, or both.

An equipment grounding conductor must be:

- Electrically continuous.
- Have ample capacity to conduct safely any currents likely to be imposed on it.
- Be of the lowest practical impedance.

Section 250.118 defines the different types of items that are allowed to be used as an equipment grounding conductor. Numbers 1-4 of this section include copper or aluminum conductors, rigid metal conduit, intermediate metal conduit, and electrical metallic tubing. These conductors or solid raceways can be used as an equipment grounding conductor with very few restrictions. Numbers 5-7 include flexible metal conduit, liquidtight flexible metal conduit, and flexible metal tubing. These flexible metal raceways are allowed to be used as equipment grounding conductors, but there are a significant number of conditions that must be met because of the nature of the flexibility of these types of raceways. Numbers 8-14 include metal sheathed cables, cable trays, gutters and the like.

Question 16: Which wiring method is NOT recognized as an equipment grounding conductor?

A: A 10 ft. section of rigid metal conduit.
B: A 6 ft. section of intermediate metal conduit.
C: A 3 ft. section of electrical metallic tubing.
D: A 8 ft. section of liquidtight flexible metal conduit.

Question 17: 250.118(5) Types of Equipment Grounding Conductors. Flexible Metal Conduit.

Question ID#: 11054.0

Flexible metal conduit is permitted as an equipment grounding conductor with 20 amperes of overcurrent protection or less.

Flexible metal conduit (FMC) is permitted to be used as an equipment grounding conductor under the following conditions:

- The fittings are listed.
- The circuit conductors in the raceway are protected at not more than 20 amps.
- The combined length of flexible metal conduit in the same ground return path does not exceed 6 feet.
- Where flexibility is necessary an equipment grounding conductor is required.

Flexible metal conduit is installed where flexibility is required during the installation. FMC can be installed in places where installing a rigid type raceway would be difficult. In approved lengths, FMC can be used as an equipment grounding conductor, as long as the flexibility is not required after the installation is complete. For example, a rotating fan that was connected with FMC would require an equipment grounding conductor installed inside the FMC. The FMC cannot serve as an equipment grounding conductor if flexibility is required after the installation.

Question 17: What is the maximum permitted length of flexible metal conduit when used as an equipment grounding conductor for a 20 amp circuit?

A: 2 ft.
B: 3 ft.
C: 6 ft.

D: 10 ft.

Question 18: 250.118(6) Types of Equipment Grounding Conductors. Liquidtight Flexible Metal Conduit.

Question ID#: 11055.0

LFMC is often used to dampen vibration or provide extra flexibility for certain equipment. Such installations, however, do not permit the conduit to be used as an equipment grounding conductor.

When an installation complies with the 5 conditions specified in 250.118(6), liquidtight flexible metal conduit (LFMC) is permitted to be used as an equipment grounding conductor (EGC). If any of the conditions are not met, a separate equipment grounding conductor is required.

The 5 conditions required for LFMC to be used as an equipment grounding conductor are as follows:

- Listed fittings are required.
- 20 amps is the maximum rating of overcurrent protection for a circuit supplied by LFMC in 3/8 inch and 1/2 inch trade sizes.
- 60 amps is the maximum rating of overcurrent protection for a circuit supplied by LFMC in 3/4 inch thru 11/4 inch and there is no LFMC smaller than 3/4 inch in the ground fault path.
- The maximum combined length of flexible metal conduit, flexible metallic tubing, and/or liquidtight flexible metal conduit in the same ground-fault current path does not exceed 6 feet.
- Where LFMC is installed to dampen vibration or to provide flexibility after installation, a separate EGC is required to be installed.

Where LFMC is installed to simplify the installation of equipment, no vibration or movement of equipment will occur after the installation is complete, and the installation complies with 250.118(6), a separate EGC is not required.

Question 18: In which of the following installations is 1/2 inch LFMC permitted to be used as an equipment grounding conductor?

A: A 1.5 HP motor on a 120 volt, 20 amp circuit supplied through an 8 foot length of LFMC.
B: A 5 HP motor on a 230 volt, 30 amp circuit supplied through a 4 foot length of LFMC.
C: A flood light on a 120 volt, 15 amp circuit supplied through a 3 foot length of LFMC.
D: A 4500 watt, 240 volt water heater on a 30 amp circuit supplied through a 3 foot length of LFMC.

Question 19: 250.119 Identification of Equipment Grounding Conductors.

Question ID#: 11056.0

Insulated equipment grounding conductors No. 6 and smaller, shall have a continuous outer finish that is either green or green with one or more yellow stripes. Larger conductors can be reidentified in the field.

Equipment grounding conductors shall be permitted to be bare, covered, or insulated. Insulated equipment grounding conductors shall have a continuous outer finish that is either green or green with one or more yellow stripes.

Equipment grounding conductors larger than No. 6 AWG shall be permitted at the time of installation to be permanently identified as an equipment grounding conductor at each end. Marking the insulation with green tape is permitted.

It is a common Code violation to install a black conductor sized No.6 AWG or smaller and re-identify it with green marking tape at its termination points. Also, a green conductor, regardless of size, is not permitted to be used as an ungrounded or grounded conductor and re-identified with marking tape at its termination points.

Question 19: Which of the following is NOT permitted as a way to identify a No. 6 AWG equipment grounding conductor?

A: Stripping the insulation from the entire length.
B: Green marking tape at each end.
C: A continuous outer finish that is green.
D: A continuous outer finish that is green with a yellow stripe.

Question 20: 250.119 Identification of Equipment Grounding Conductors. Exception.

Question ID#: 11057.0

There are exceptions to the main rule in 250.119 that requires insulated equipment grounding conductors to be green in color and prohibits conductors with green insulation to be used as ungrounded or grounded circuit conductors.

Exception No. 1 applies to limited power and Class 2 and Class 3 applications, where the voltage is ***less than 50 volts***, and permits a green conductor to be used for other than equipment grounding purposes. In order for this exception to apply, the equipment involved must be connected to remote-control, signaling, and fire alarm circuits that are not required to be grounded.

Many low voltage control applications, such as a thermostat cable controlling an air conditioning fan, use the green wire as an ungrounded conductor. Traffic signaling circuits also use the green wire in control applications as an ungrounded conductor. In traffic control cables the red wire supplies the red signal, the yellow wire supplies the yellow signal and the green wire supplies the green signal. The green wire has been used as an ungrounded conductor in low voltage systems for many years.

Also, conductors 4 AWG and larger are permitted to be permanently identified as an equipment grounding conductor at each end and at every point where the conductor is accessible.

Conductors larger than No. 6 AWG are not required to have a continuous green outer finish.

Question 20: Which of the following applications permit a conductor with green insulation inside a cable to be used for other than equipment grounding purposes?

A: Traffic control devices operating at 60 VDC.
B: Fire alarm annunciators operating at 120 VAC.
C: Computer control circuits operating at 48 VDC.
D: HVAC damper control circuits operating at 50 VDC.

Question 21: 250.119(B) Identification of Equipment Grounding Conductors. Multiconductor Cable.

Question ID#: 11058.0

The re-identification of conductors in multiconductor cables as equipment grounding conductors is required at every device, junction box, distribution panel, or other location where the wiring is accessible.

In locations such as industrial plants and buildings serviced by professional maintenance technicians, where all the personnel are qualified persons, a conductor in a multiconductor cable can be permanently identified as an equipment grounding conductor at each end and at every point where the conductor is accessible.

These conductors in multiconductor cables can be identified as equipment grounding conductors, even if they are No. 6 AWG or smaller, by marking the exposed insulation with green tape or green adhesive labels. Other accepted means of identification are stripping the insulation from the entire exposed length of the conductor, or coloring the exposed insulation green.

The re-identification of conductors in multiconductor cables as equipment grounding conductors is required at every device, junction box, distribution panel, or other location where the wiring is accessible.

Question 21: In a building where only qualified persons service the electrical system, which of the following statements about the identification of equipment grounding conductors is true?

A: In multiconductor cables, a No. 8 AWG must only be identified by solid green insulation.
B: Conductors with their insulation stripped away are not permitted as equipment grounding conductors in multiconductor cables.
C: Factory authorized technicians can use green tape to identify a black conductor as an equipment grounding conductor in multiconductor cables.
D: Conductors that have been re-identified as equipment grounding conductors at terminations of multiconductor cables are not required to be re-identified at junction boxes where conductors are spliced.

Question 22: 250.120(A) Equipment Grounding Conductor Installation. Raceway, Cable Trays, Cable Armor, Cablebus, or Cable Sheath.

Question ID#: 11059.0

Conduit runs of rigid and intermediate metal conduit that are properly threaded and EMT in which the couplings are made up wrench-tight, can be expected to perform well as an equipment grounding conductor by carrying fault current under fault conditions.

It is important that all connections and fittings be made up tight using suitable tools when joining raceways and wiring methods that enclose ungrounded circuit conductors. This is especially important when using the metal raceway as an equipment grounding conductor and relying on it for the purpose of carrying ground-fault current back to the source in order to open an overcurrent device.

Some jurisdictions make amendments to the Code that require an equipment grounding conductor to be installed inside all metal raceways even if the Code would normally allow the raceway itself to be used as an equipment grounding conductor. This is because it is difficult to be sure that all installed raceway fittings have been made up tight and will function properly to carry ground-fault current back to the source at the service or transformer.

This installation utilizes EMT and couplings made up wrench-tight to maintain effective ground fault path.

Question 22: Which of the following is a true statement?

A: Suitable tools must be used to tighten conduit and fittings.
B: Conduit and fittings can be hand-tight if an equipment grounding conductor is installed in the conduit.
C: A torque wrench is required to tighten conduit and fittings.
D: A socket wrench is required to tighten conduit and fittings.

Question 23: 250.120(B) Equipment Grounding Conductor Installation. Aluminum and Copper Clad Aluminum Conductors.

Question ID#: 11060.0

Aluminum may be used anywhere conductors will not be subject to corrosion.

Bare or insulated aluminum or copper-clad aluminum equipment grounding conductors shall be permitted. Bare conductors shall not come in direct contact with masonry, the earth or any location where subject to corrosive conditions. Aluminum or copper-clad aluminum conductors shall not be terminated within 18 inches of the earth.

Corrosion is the wearing away of metals due to a chemical reaction. Swimming pools and coastal areas are considered corrosive environments.

There are several Code sections that have similar requirements for aluminum conductors. Aluminum does not have the same corrosion-resistant characteristics as copper and must not be used in certain applications where reactions would occur that would compromise the integrity of the conductor. See the following sections where only a copper conductor is permitted to be used in a corrosive atmosphere: 250.64(A), 553.8(C), 555.15(B), 680.23(B)(2), 680.25(A)(2).

Question 23: Which of the following bare aluminum equipment grounding conductors is code compliant?

A: One that terminates 6 inches from the earth.
B: One that terminates 12 inches from the earth.
C: One that terminates 17 inches from the earth.
D: One that terminates 24 inches from the earth.

Question 24: Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment.

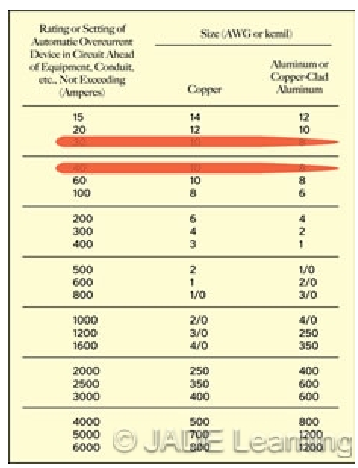
Question ID#: 11061.0

Section 250.122(A) provides the general rules for sizing the equipment grounding conductor. It refers to Table 250.122 for determining the minimum size conductor that is permitted to be used as an equipment grounding conductor.

Equipment grounding conductors are sized based on the ampere rating of the overcurrent protective device that is located ahead of the conductor, and they are never required to be larger than the circuit conductors supplying the equipment.

A striking feature of Table 250.122 is how much smaller the required equipment grounding conductor can be compared to the ungrounded conductors, especially in larger circuits. A copper equipment grounding conductor for a 200 amp circuit can be No. 6 AWG. The ungrounded conductors would be 3/0 AWG. The equipment grounding conductor for a 400 amp circuit can be No. 3 AWG. The ungrounded conductor would need to be 500 kcmil.

The reason for this striking difference is that an equipment grounding conductor is only required to carry current for a fraction of second. An equipment grounding conductor can carry large fault currents for a short period of time, and if selected from Table 250.122, it will be sized correctly.



Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	800
5000	700	1200
6000	800	1200

Size is based on the ampere rating of the overcurrent protective device that is located ahead of the conductor.

Question 24: A commercial oven requires a 60 amp branch circuit. What is the minimum size copper equipment grounding conductor?

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

Question 25: 250.122(B) Size of Equipment Grounding Conductors. Increased in Size.

Question ID#: 11062.0

The general requirement for selecting the minimum size equipment grounding conductor is to select directly from Table 250.122 based on the rating or setting of the feeder or branch-circuit overcurrent protective device.

When the ungrounded circuit conductors are increased in size to compensate for voltage drop, 250.122(B) requires that the equipment grounding conductors be increased proportionately. If the size of the ungrounded conductors are increased by 25% to reduce voltage drop, the equipment grounding conductor must also be increased in size by 25%. The equipment grounding conductor is not required to be increased in size if the ungrounded conductors are increased because the circuit has more than three current carrying conductors in conduit or because the ambient temperature is hotter than 86Â°F.

If ungrounded conductors are increased in size to allow for voltage drop, the equipment grounding conductors must be increased by the same percentage.

For example, a circuit that uses 250 kcmil ungrounded conductors and is protected by a 300 amp overcurrent device requires a No. 4 AWG cu. equipment grounding conductor. If the ungrounded conductors are increased from 250 kcmil to 350 kcmil (a 40% increase), the equipment grounding conductor must be increased by the same percentage, 40%. Table 8 is used to find the circle mil area of conductors. A No. 4 AWG conductor is 41,740 circular mils. 41,740 cir. mils x 1.4 = 58,436 cir. mils. From Table 8, the required equipment grounding conductor must be a No. 2 AWG.

If the ungrounded conductors are increased in size because of a hot ambient temperature, or because there are more than 3 current-carrying conductors in conduit, the equipment grounding conductor is not required to be increased in size.

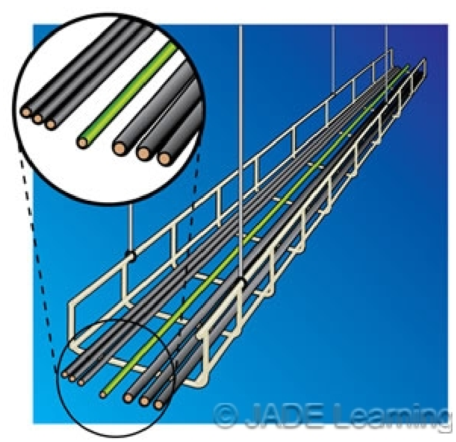
Question 25: If the ungrounded supply conductors for a feeder circuit are increased by 15% to compensate for voltage drop, what are the requirements for the equipment grounding conductor?

A: The equipment grounding conductor must be increased in size by 25%.
B: The equipment grounding conductor is not required to be increased in size.
C: The equipment grounding conductor must be increased in size by 40%.
D: The equipment grounding conductor must be increased in size by 15%.

Question 26: 250.122(C) Size of Equipment Grounding Conductors. Multiple Circuits.

Question ID#: 11063.0

The Code permits a single equipment grounding conductor to serve several circuits that are in the same raceway. The equipment grounding conductor is required to be sized for the rating of the largest overcurrent device of the group.



The Code permits a single equipment grounding conductor to serve several circuits that are in the same raceway. The equipment grounding conductor is required to be sized for the rating of the largest overcurrent device of the group.

This is extremely helpful in a situation where multiple branch circuits are installed in a run of non-metallic conduit between a panelboard and an auxiliary gutter or wireway. Instead of an individual equipment ground for each circuit in the same raceway, a single equipment grounding conductor is permitted to be used.

For example, a PVC conduit contains multiple branch circuit conductors that have overcurrent protection rated: 30 amperes, 50 amperes and 70 amperes. The largest overcurrent device serving conductors in the same raceway in this case is rated 70 amps. Based on table 250.122, and the 70 amp overcurrent device, a single No. 8 AWG equipment grounding conductor is permitted to serve all the branch circuits in the raceway.

Question 26: A single conduit contains circuits rated 20 amps, 50 amps and 100 amps. What is the minimum size of the required equipment grounding conductor?

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

Question 27: 250.122(F) Size of Equipment Grounding Conductors. Conductors in Parallel.

Question ID#: 11064.0

A full sized equipment grounding conductor is required in each raceway when paralleled conductors are installed in multiple raceways.

Special rules apply when more than one raceway is installed with paralleled ungrounded conductors and an equipment grounding conductor. Each equipment grounding conductor in each raceway is required to be sized according to the ampere rating of the overcurrent device protecting the conductors in the raceway. In other words, a full size equipment grounding conductor is required in each raceway of the parallel run.

In the event of a line-to-ground fault in the equipment supplied by the circuit, the fault current should divide equally between the equipment grounding conductors. Section 310.10(H) permits parallel equipment grounding conductors to be sized in compliance with Table 250.122. However, all other requirements for installing conductors in parallel must be met, including the requirement that the smallest conductor which can be installed in parallel is a No. 1/0 AWG.

Regardless of whether a single raceway or multiple raceways are used to enclose parallel conductors, the equipment grounding conductor in each raceway is still required to be sized based on the overcurrent device protecting the circuit conductors. Assuming copper conductors are used, if four PVC raceways are enclosing parallel conductors fed from a 1600 amp overcurrent device, then based on Table 250.122 and the 1600 amp overcurrent device, each raceway must also contain a No. 4/0 AWG equipment grounding conductor. If one raceway is enclosing all of the parallel conductors fed from the 1600 amp overcurrent device, then based on Table 250.122 and the 1600 amp overcurrent device, this one raceway must also contain a 4/0 AWG equipment grounding conductor.

Question 27: A 3-phase parallel feeder is installed in twelve, 4 inch PVC conduits. Each of the 12 PVC conduits includes one 600 kcmil copper conductor for each of the 3 ungrounded phase conductors and a copper equipment grounding conductor.

If the parallel feeder is protected by a 5000 -ampere overcurrent device, what is the minimum size copper equipment grounding conductor required in each conduit?

A: 350 kcmil.
B: 500 kcmil.
C: 600 kcmil.
D: 700 kcmil.

Part VII Methods of Equipment Grounding

Question 28: 250.130(C) Equipment Grounding Conductor Connections. Nongrounding Receptacle.

Question ID#: 11066.0

There are specific conditions for replacing a non-grounding receptacle with a grounding-type receptacle.

Section 250.130(C) permits a nongrounding-type receptacle to be replaced with a grounding-type receptacle under the following conditions:

- The branch circuit does not contain an equipment ground.
- An equipment grounding conductor is connected from the receptacle grounding terminal to any accessible point on the grounding electrode system, to any accessible point on the grounding electrode conductor, to the grounded service conductor within the service equipment enclosure, to an equipment grounding conductor that is part of another branch circuit that orginates in the same enclosure, or to the equipment grounding terminal bar in the enclosure from which the circuit is supplied.

Nongrounding receptacles are used on branch circuits where there is no equipment ground. Most installers use a GFCI protected receptacle as the first outlet on the circuit to protect the downstream outlets, per 406.4(D)(2). However, section 250.130(C) permits a grounding receptacle to replace a nongrounding receptacle if a ground fault path is established between the grounding type receptacle which replaces the nongrounding receptacle and the panelboard where the circuit originates, or to the service.

Section 250.130(C)(4) also permits an equipment grounding conductor for the replacement receptacle to be connected to an equipment grounding conductor of another branch circuit which originates from the same enclosure where the branch circuit for the original non-grounding type receptacle originated.

Question 28: When replacing a nongrounding receptacle with a grounding type receptacle, where can an equipment grounding conductor connected to the grounding terminal of the grounding-type receptacle be connected?

A: A metal box.
B: A metal raceway.
C: The grounding electrode system.
D: The branch circuit neutral conductor.

Question 29: 250.134 Equipment Fastened in Place or Connected by Permanent Wiring Methods (Fixed) - Grounding.

Question ID#: 11067.0

The equipment grounding conductor of a 4-wire branch circuit must be used to ground the non-current-carrying metal parts of equipment.

The non-current-carrying metal parts of equipment that are fastened in place or connected by permanent wiring methods must be connected to an equipment grounding conductor that is run with the circuit conductors, or to one of the equipment grounding conductors listed in 250.118.

This is the general rule, and except for special circumstances, the grounded conductor cannot be used to ground non-current-carrying metal parts of equipment.

By requiring that non-current-carrying metal parts of equipment are connected to an equipment grounding conductor, and prohibiting the grounded conductor from being used to ground equipment, the National Electrical Code is saying the equipment grounding path and the path for normal grounded neutral current must be kept separate. The equipment grounding conductor is only used to carry fault current, and the grounded neutral conductor is only used to carry unbalanced neutral current.

Question 29: Which of the following is NOT permitted to be used to ground non-current-carrying parts of an electric range that is supplied by a 40 amp branch circuit?

A: A green stranded No. 10 AWG copper equipment grounding conductor.
B: A green solid No. 10 AWG copper equipment grounding conductor.
C: A bare stranded No. 8 AWG aluminum equipment grounding conductor in type SER cable.
D: A solid white No. 10 AWG copper grounded circuit conductor.

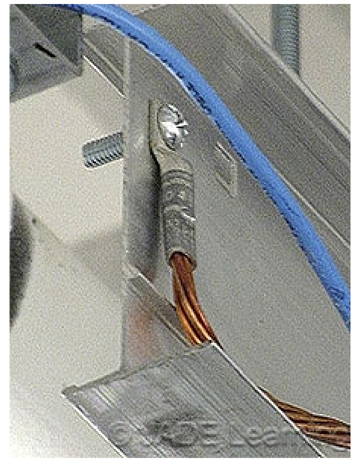
Question 30: 250.136(A) Equipment Considered Grounded. Equipment Secured to Grounded Metal Supports.

Question ID#: 11068.0

Instead of installing one of the equipment grounding conductor types specified in 250.118 to each piece of equipment supported by a common metal rack, the NEC permits the equipment to be grounded by its mechanical attachment to a rack that is grounded through one or more connections to an equipment grounding conductor.

Equipment bolted to a rack will provide the necessary electrical contact to ensure that there is a low impedance connection between the rack and the equipment. An equipment bonding jumper must connect the metal rack to an equipment grounding conductor that provides a fault return path back to the supply source, either at the service or at a separately derived system.

The structural metal frame of a building cannot be used as the required fault return path. A metal rack that supports electrical equipment, and is fastened to the building steel, needs an equipment bonding jumper that connects the metal frame to an equipment grounding conductor.



Equipment bolted to a rack will provide the necessary electrical contact to ensure that there is a low impedance connection between the rack and the equipment.

Question 30: When can the structural metal frame of a building be used as an equipment grounding conductor for AC equipment?

A: Always.
B: Never.
C: The AC equipment is within 6 ft. of the structural metal frame of the building.
D: The branch circuit overcurrent protection does not exceed 60 amps.

Question 31: 250.138 Cord-and-Plug-Connected Equipment.

Question ID#: 11069.0

Section 250.138 requires non-current-carrying parts of grounded equipment that is cord-and-plug connected to be connected to an equipment grounding conductor by one of the means in 250.138 (A) or (B).

Section 250.138 requires non-current-carrying parts of grounded equipment that is cord-and-plug connected to be connected to an equipment grounding conductor by one of the means described in 250.138(A) or (B).

The method described in 250.138(A) is the most commonly used method for grounding new listed cord-and-plug-connected equipment. It requires the equipment grounding conductor to be run with the power supply conductors as part of a flexible cord or cable assembly and to be terminated in a grounding type plug with a fixed grounding contact.

Section 250.138(B) permits an alternate method of grounding cord-and-plug-connected equipment. The equipment is grounded by means of a separate insulated or bare flexible wire or strap that is part of the equipment and which is connected to an equipment grounding conductor and protected from physical damage.

Question 31: Which of the following statements about cord-and-plug-connected equipment is true?

A: Equipment must only be grounded by an equipment grounding conductor that is part of a flexible cord, terminated in a grounding type plug.
B: Equipment must only be grounded by an equipment grounding conductor that is part of a cable assembly, terminated in a grounding type plug.
C: Equipment that is not grounded by an equipment grounding conductor that is part of a flexible cord or cable assembly can only be grounded by a separate insulated flexible wire.
D: Non-current-carrying metal parts of grounded cord-and-plug-connected equipment are required to be connected to an equipment grounding conductor.

Question 32: 250.140 Frames of Ranges and Clothes Dryers.

Question ID#: 11070.0

Frames of ranges and clothes dryers must be grounded by connection to an ***equipment grounding conductor***. There is a difference between an equipment grounding conductor (***green or bare conductor***)and a grounded conductor(***white conductor***).

The exception to Section 250.140 applies to existing branch circuits that were installed under previous editions of the NEC. The exception permits use of the grounded circuit conductor (***white conductor***) to be used to ground the frames of ranges, counter-mounted cooking units, wall-mounted ovens, clothes dryers, and associated outlets or junction boxes, provided the installation complies with ***ALL*** of the following requirements:

- The equipment is supplied by a 120/240-volt, 3-wire circuit(***two hot wires and a white wire***), or a 208Y/120-volt circuit(***two hot wires and a white wire***) derived from a 3-phase, 4-wire wye-connected system(***three hot wires and a white wire***). ***Note, no equipment ground is present in any of these, thus the exception is permitted.***
- The minimum size grounded branch circuit conductor is not smaller than a No. 10 AWG copper or a No. 8 AWG aluminum.
- The grounded conductor is insulated unless it is an uninsulated conductor in a SE cable terminated in the service equipment.
- Any grounding contacts in receptacles integral to the equipment are bonded to the equipment frame.

The exception to Section 250.140 only applies to existing branch circuits that were installed in compliance with previous editions of the NEC.

The installation described in the exception was the general rule rather than an exception prior to the 1996 NEC. Since 1996, the frames of ranges and clothes dryers have been grounded by connection to an equipment grounding conductor.

The practice of using the grounded conductor for grounding ranges was introduced in ***Supplement to the 1940 NEC.*** During World War II there was a critical shortage of copper which was needed for defense industries. In addition to a shortage of copper, the war created a shortage of rubber which was used for insulating conductors.

In response to these two shortages caused by the war, the NEC was revised to permit electric ranges to be grounded by an insulated grounded conductor or an uninsulated grounded conductor in type-SE Cable.

Since 1996, in new construction, the NEC has required that a separate equipment grounding conductor be used for grounding the frames of ranges, wall-mounted ovens, cooktops, dryers, and associated junction boxes. This change requires 4 conductor branch circuits and/or 4-wire cords and 4 terminal receptacles for these appliances.

NOTE: The installation described in the exception was the general rule rather than an exception prior to the 1996 NEC. Since 1996, the frames of ranges and clothes dryers have been grounded by connection to an equipment grounding conductor.

Question 32:   Which of the following is a National Electrical Code violation?

A: Using the grounded conductor to ground the frame of a clothes dryer in an existing installation.
B: Using the grounded conductor to ground the frame of an electric range in an existing installation.
C: In a new installation, using the copper grounded conductor in a 10/3 NM cable to ground the frame of a clothes dryer.
D: In a new installation, grounding the frame of a cooktop with a bare No. 10 copper equipment grounding conductor that is part of a 3-wire-with-ground NM cable.

Question 33:   250.142 Use of Grounded Circuit Conductor for Grounding Equipment.

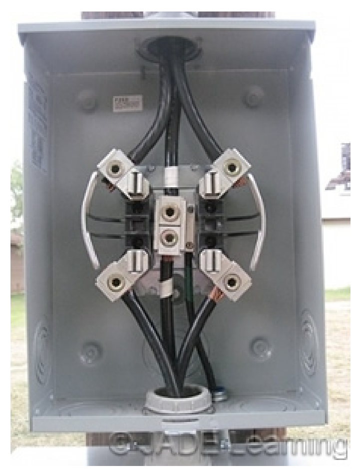
Question ID#: 11071.0

Section 250.142 permits the use of the grounded service conductor for grounding equipment on the supply side of the service disconnecting means.

Connecting the grounded service conductor to equipment such as meter bases, wireways or auxiliary gutters on the supply side of the service disconnecting means is a practical way of grounding these enclosures.

There are only a few exceptions that allow using a grounded circuit conductor for grounding non-current-carrying metal parts on the load side of the service disconnecting means.

The danger of grounding a neutral conductor on the load side of the service is if the grounded conductor loses its connection at the main service. If that happens there is neutral return current flowing through metal enclosures, metal raceways and any equipment where a grounded conductor and an equipment grounding conductor have contact. With return current flowing through normally grounded equipment, there is a potential shock hazard if one were to inadvertently touch the equipment while also touching grounded metal parts or systems that were not at the same potential to ground.



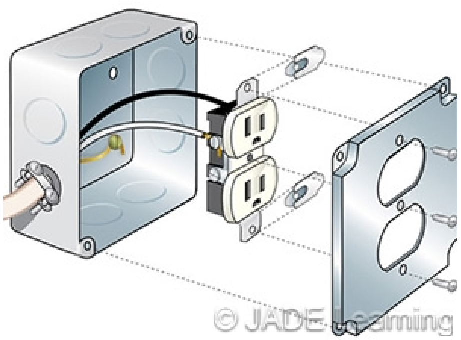
250.142 permits the use of the grounded service conductor for grounding equipment on the supply side of the service disconnecting means.

Question 33: Where can a grounded circuit conductor ground non-current-carrying metal parts of equipment?

A: At the service-disconnecting means.
B: At a subpanel.
C: At a water heater.
D: At a gas furnace.

Question 34: 250.146 Connecting Receptacle Grounding Terminal to Box.

Question ID#: 11072.0



The bonding jumper is required to be sized in accordance with Table 250.122 and the rating of the overcurrent device that supplies the circuit.

The general rule in this section requires that an equipment bonding jumper be connected between the grounding terminal of a grounding-type receptacle and a metal box in which the receptacle is installed. The bonding jumper is required to be selected from Table 250.122 based on the rating of the overcurrent device that supplies the circuit.

However, installation of an equipment bonding jumper is not required in any of the four following installations:

- A surface-mounted metal box where there is direct contact between the metal receptacle yoke and the metal box provided at least one of the fiber washers is removed from the mounting screw. Also, where the receptacle is secured to an exposed work metal cover by two rivets or other permanent metal devices, and the cover mounting holes are in a non-raised part of the cover.
- The receptacle yoke is a listed self-grounding type secured to the box with metal screws.
- The receptacle is installed in a floor mounted box that is listed for grounding the receptacle.
- Isolated receptacles are not required to be bonded to the box in which they are installed provided the grounding terminal is connected to an insulated equipment grounding conductor that is installed with the circuit conductors and routed back to the service equipment. At the service it is connected to the equipment grounding busbar. However, metal raceways, cable armor, and/or boxes in which conductors that supply the isolated receptacle are installed are required to be grounded by one of the methods in 250.118.

Question 34: Which of the following statements about bonding receptacles to metal boxes is correct?

A: A bonding jumper is always required to connect the grounding terminal of a receptacle to the box in which it is installed.
B: Where a receptacle is mounted flush with the wall surface, if the box is grounded the yoke of the receptacle can be used to ground the receptacle.
C: Where a receptacle is surface-mounted, the yoke of the receptacle can be used to ground the receptacle if one of the fiber washers is removed from the receptacle.
D: When isolated receptacles are used, receptacle boxes and raceways are not required to be grounded.

Question 35: 250.148 Continuity and Attachment of Equipment Grounding Conductors to Boxes.

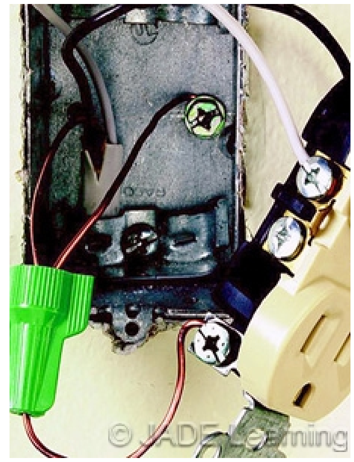
Question ID#: 11073.0

If circuit conductors are spliced or terminated on devices or equipment in a box, any equipment grounding conductors installed with the circuit are required to be connected to the box by listed devices. Such devices for attaching an equipment grounding conductor to a box include listed grounding screws, listed grounding clips, and other listed devices. Grounding connections are not permitted to be solely dependent on solder.

The removal of receptacles, luminaires, or other devices or equipment installed in or on boxes is not permitted to interrupt or break the continuity of the grounding connections to other equipment or devices that are supplied from the box where grounding conductors are connected. The equipment grounding conductors must be spliced together and a bonding jumper must be connected to the receptacle or luminaire.

If metallic raceways are used as the equipment grounding conductor in accordance with 250.118, wire type equipment grounding conductors are not required to be used for grounding boxes or conduit bodies such as T's or LB's that are installed as part of the raceway system, provided circuit conductors are not spliced or terminated to equipment in metal boxes or conduit bodies.

Equipment grounding conductors installed in nonmetallic outlet boxes are required to provide a means of connecting equipment grounding conductors to receptacles, switches, luminaires, and other equipment installed in or supplied from the nonmetallic box.



If circuit conductors are spliced or terminated on devices or equipment in a box, any equipment grounding conductors installed with the circuit are required to be connected to the box by listed devices.

Question 35: Which of the following is a violation of NEC requirements for grounding?

A: Connecting a correctly sized solid equipment grounding conductor to an outlet box with a listed grounding clip.
B: In a RMC conduit system, failure to connect a metal conduit body where no conductors are terminated or spliced to an insulated equipment grounding conductor installed in the RMC.
C: Where conductors are installed in ENT, failure to connect an equipment grounding conductor to a metal junction box where conductors including an insulated equipment grounding conductor are spliced.
D: Using an insulated equipment grounding conductor to ground receptacles installed in a metal box grounded by a RMC raceway system.

Question 36: 250.148(C) Continuity and Attachment of Equipment Grounding Conductors to Boxes. Metal Boxes.

Question ID#: 11074.0

A grounding screw shall be used for no other purpose.

When equipment grounding conductors are spliced or attached to a device in a metal box, the box must be grounded. The box is grounded by making a connection between the equipment grounding conductors entering the box and the metal box.

Machine screws are acceptable connection methods. The machine screws cannot be used for any other purpose than grounding the box; they cannot be cover screws. Other type screws such as sheet metal and wood screws are not permitted. Machine screws have fine threads and make a secure connection to the box. Sheet metal and wood screws have course threads which can work loose and create a high resistance connection.

Per section 250.8, the machine screws must engage not less than two threads or must be secured by a nut.

Question 36: The connection between the equipment grounding conductors and a metal box shall be made by all of the following except:

A: A sheet metal screw.
B: A listed grounding device.
C: Equipment listed for grounding.
D: A grounding screw used for no other purpose.

Part X Grounding of Systems and Circuits of over 1kV

Question 37: 250.190(C) Grounding of Equipment. Equipment Grounding Conductor.

Question ID#: 11076.0

The general requirement in 250.190 requires all non-current-carrying metal parts of equipment operating over 1,000 volts to be grounded. There is an exception which permits non-current-carrying metal parts of such equipment to be ungrounded while the equipment is energized provided the ungrounded parts are located so that they cannot be contacted by a person who is simultaneously in contact with ground. In the exception, the word ***ground*** means earth as well as anything that is effectively grounded to the earth such as metal raceways and grounded structural steel.

Equipment grounding conductors are required for medium voltage circuits.

Section 250.190(C)(1), (2) and (3) describe the types of equipment grounding conductors required for grounding non-current-carrying parts of equipment operated at more than 1,000 volts as follows:

- The minimum size of wire type equipment grounding conductors that are not an integral part of a cable is No. 6 AWG copper or No. 4 AWG aluminum.
- A metallic shield that completely surrounds a current carrying conductor is permitted to be used as an equipment grounding conductor, provided the shield is rated to clear ground fault current fast enough to prevent damage to the metallic shield. On solidly grounded systems, the drain wire insulation shield and/or metallic tape insulation shield are not permitted to be used as equipment grounding conductors.
- Equipment grounding conductors that are separately installed as specified in 250.190(C)(1) and conductors in a cable assembly are required to be sized in accordance with Table 250.122 provided they are not smaller than No.6 cu or No. 4 AL.

Question 37: In systems where the voltage is greater than 1,000 volts, what is the minimum size of a separate copper equipment grounding conductor if the ungrounded circuit conductor is protected by an overcurrent relay which opens the circuit at 30 amps?

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

Applications

Question 38:   310.10(H)(5) Conductors in Parallel. Equipment Bonding Conductors.

Question ID#: 11078.0

Equipment bonding conductors are installed with each parallel run of ungrounded conductors.

Conductors are commonly installed in parallel for large capacity feeders and services because it is less expensive and more practical to install smaller conductors in parallel than it is to install single runs of larger conductors.

For example, two, 500 kcmil, 75 degree C conductors installed in parallel can carry 760 amps. A single 1000 kcmil, 75 degree C conductor is rated for only 545 amps. Installing 500 kcmil conductors is much easier than installing 1000 kcmil conductors.

The general requirement is that equipment bonding conductors that are connected in parallel are required to be sized in accordance with Table 250.122, based on the rating of the overcurrent protective device protecting the circuit. Each parallel run of ungrounded conductors must have a full sized equipment bonding conductor, based on the size of the overcurrent device protecting the circuit, and selected from Table 250.122.

Equipment bonding conductors are permitted to be connected in parallel in single or multiple raceways. When ungrounded conductors are installed in parallel in multiple raceways, equipment bonding conductors are required to be installed in each raceway and connected in parallel at both ends.

Question 38:   If a 3-phase, 277/480 volt feeder is protected by a 800 amp overcurrent device, what is the minimum size copper equipment bonding conductors that are installed in each of two parallel raceways?

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

Question 39:   404.9(B) Provisions for General-Use Snap Switches. Grounding.

Question ID#: 11079.0

The general rule in section 404.9(B) requires snap switches, dimmers, and similar control devices to be grounded. These devices are also required to provide a way for metal faceplates, whether or not they are installed, to be connected to an equipment grounding conductor after the initial installation is complete.

Snap switches, dimmers, and similar control devices must be grounded and provide a way to ensure continuity with metal faceplates.

Snap switches are considered grounded as long as the installation complies with one of the two following requirements:

- The switch or similar device is secured with metal screws to either a metal box or metal cover that is connected to an equipment grounding conductor; or the switch is installed in a nonmetallic box that has an integral means of connecting the switch to an equipment grounding conductor.
- The switch itself is connected to either an equipment grounding conductor or is bonded to a box that is connected to an equipment grounding conductor.

An important exception for older wiring without an equipment grounding conductor allows an ungrounded snap switch as a replacement for an existing switch if (1) the replacement switch has a nonconductive faceplate attached with nonconductive screws, or (2) the circuit is protected by GFCI.

Two other exceptions permit an ungrounded switch to be installed if it is part of a listed assembly or if the switch has an integral nonmetallic enclosure.

Question 39: Which of the following statements about the grounding of switches is correct?

A: All snap switches are required to be grounded, even if there is not an equipment grounding conductor present.
B: All snap switches installed in metal boxes are required to be grounded, even if there is not an equipment grounding conductor present.
C: In new construction, a snap switch is considered grounded if the snap switch is connected to an equipment grounding conductor.
D: Replacement switches that are within 5 feet horizontally of a grounded surface are required to be GFCI protected.

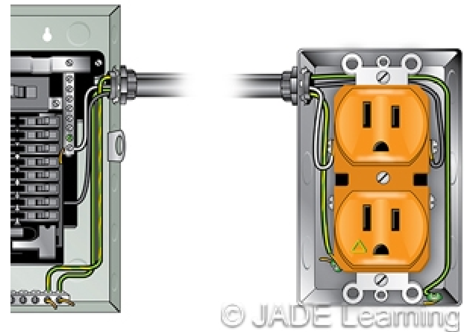
Question 40: 406.3(D) Receptacle Rating and Type. Isolated Ground Receptacles.

Question ID#: 11080.0

An isolated ground receptacle is a receptacle in which the grounding terminal is purposely insulated from the receptacle mounting means. Isolated receptacles are installed to reduce electrical noise on the sensitive electronic equipment that is plugged into the outlet.

The equipment grounding terminal is required to be grounded by an insulated equipment grounding conductor that is run with the circuit conductors. Isolated ground receptacles shall be identified by an orange triangle located on the face of the receptacle.

Isolated grounding-type receptacles have no continuity between the isolated grounding terminal on the device and their own metal mounting strap or yoke. When using an isolated ground receptacle in a metal box, the metal box must still be grounded. If the metal raceway qualifies as an equipment grounding conductor, then the raceway can ground the box. Or an additional equipment grounding conductor can be installed in the raceway.



The equipment grounding terminal is required to be grounded by an insulated equipment grounding conductor that is run with the circuit conductors.

Question 40: Which of the following statements about isolated ground receptacles is true?

A: An isolated ground receptacle is not connected to an equipment grounding conductor.
B: An isolated ground receptacle is identified by a red triangle on the face of the receptacle.
C: If the isolated ground receptacle is mounted in a metal box, the box must be grounded by a separate equipment grounding conductor in addition to the one that is connected to the receptacle.
D: The equipment grounding conductor that is connected to the isolated ground receptacle must have solid orange insulation.

Question 41: 406.4 General Installation Requirements.

Question ID#: 11081.0

Except where installed as replacements for non-grounding-type receptacles, all receptacles installed on 15 and 20 amp branch circuits are required to be grounding-type receptacles.

The grounding terminals of cord connectors and receptacles are required to be connected to an equipment grounding conductor unless covered by one of the two exceptions to the general rule:

1. Replacement receptacles where an equipment grounding conductor is not present.

2. Receptacles installed on vehicle-mounted and portable generators.

Except as replacements, receptacles installed on 15 and 20 amp circuits are required to be grounding-type receptacles.

Replacement Receptacles: Where it is impracticable to replace a non-grounding receptacle with a GFCI receptacle because of the box size or other reason, non-grounding receptacles are permitted to be replaced with new non-grounding-type receptacles that are GFCI protected, provided they are marked "GFCI Protected" and also marked "No Equipment Ground." Where practicable, the NEC permits replacement of non-grounding receptacles with GFCI-type receptacles or grounding-type receptacles that are GFCI protected and that are marked "GFCI Protected" and also marked "No Equipment Ground."

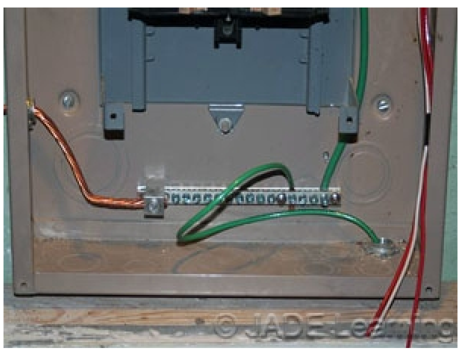
If replacement receptacles are installed, the replacement is required to comply with the NEC requirements that would apply to receptacles being installed in new construction. For example, if under the current NEC, receptacles are required to have AFCI protection, GFCI protection, or to be Tamper-Resistant or Weather-Resistant, the replacement receptacles must provide that same type of protection. AFCI and GFCI receptacle outlets must be readily accessible.

Question 41:   Which of the following is an acceptable way to replace a non-grounding-type receptacle with a grounding-type receptacle?

A: Connect an equipment grounding jumper from the receptacle to the box.
B: Connect an equipment grounding jumper from the receptacle to a grounded object.
C: Connect an equipment grounding jumper from the grounded neutral terminal of the receptacle to the equipment grounding terminal of the receptacle.
D: Install a GFCI receptacle marked "No Equipment Ground" in place of the non-grounding receptacle.

Question 42:   408.40 Grounding of Panelboards.

Question ID#: 11082.0



Section 408.40 requires the cabinet, frame, and other non-current carrying parts of metal panelboards to be grounded by being connected to an equipment grounding conductor.

Section 408.40 requires the non-current-carrying parts of metal panelboards to be grounded by being connected to an equipment grounding conductor. It also requires the installation of an equipment grounding conductor terminal bar which is bonded to the panelboard enclosure. Feeder and branch-circuit equipment grounding conductors are terminated on the panelboard's equipment grounding terminal bar.

An exception does permit insulated, isolated equipment grounding conductors for isolated ground circuits to pass through panelboards without being terminated in the panelboard so that they can be terminated on the equipment grounding conductor terminal bar in the service equipment.

At the electric service, the equipment grounding conductors can be connected to a terminal bar in a panelboard that is used for grounded conductors. In service equipment, neutral conductors as well as equipment grounding conductors of feeders and branch circuits are terminated on the equipment grounding terminal bar.

In panelboards that are not used as service equipment, equipment grounding conductors and grounded conductors must be connected to separate terminal bars. The terminal bar for the equipment grounding conductors is bonded to the panelboard enclosure. The terminal bar for the grounded conductors is isolated from the panelboard enclosure.

Question 42:   Which of the following statements about a metal panelboard that is not used as service equipment is true?

A: Grounded neutral conductors and equipment grounding conductors are required to be terminated on the equipment grounding terminal bar.
B: Grounded neutral conductors are bonded to the panelboard.
C: Equipment grounding conductors are terminated on an isolated terminal bar that is not bonded to the panelboard enclosure.
D: Equipment grounding conductors are terminated to an equipment grounding terminal bar that is bonded to the panelboard enclosure.

Question 43: 410.44 Luminaires, Lampholders, and Lamps. Methods of Grounding.

Question ID#: 11083.0

Luminaires and associated equipment are required to be connected to one of the 14 types of equipment grounding conductors that are listed in 250.118 and sized as required by 250.122.

The general rule in 410.44 requires that luminaires and associated equipment be connected to one of the 14 types of equipment grounding conductors that are listed in 250.118. If an equipment grounding conductor is used, it must be selected from Table 250.122.

There are three exceptions to the general rule:

- Luminaires that are made of nonconductive material and that do not include any means of attaching an equipment grounding conductor are not required to be grounded.
- When a luminaire is replaced on a circuit without an equipment grounding conductor, the non-current-carrying metal parts of the new luminaire can be connected to the grounding electrode system, the grounding electrode conductor, the equipment grounding bar in the subpanel where the circuit originates, or at the grounded terminal bar within the service equipment.
- If equipment grounding conductors are not present, and the supply is from a GFCI protected circuit, the luminaire is not required to be grounded.

Question 43: Which of the following statements about the grounding of luminaires is correct?

A: All types of luminaires are required to be grounded.
B: When installed in a location without an equipment grounding conductor, replacement luminaires are not required to be connected to an equipment grounding conductor when supplied by a GFCI protected circuit.
C: Only luminaires that are supplied by circuits containing an equipment grounding conductor are required to be grounded.
D: Luminaires that include provisions for connection to an equipment grounding conductor are always required to be connected to an equipment grounding conductor.

Question 44: 410.44 Exception No. 3. Luminaires, Lampholders, and Lamps. Methods of Grounding.

Question ID#: 11084.0

If equipment grounding conductors are not present, and the supply is from a GFCI protected circuit, the luminaire is not required to be grounded.

Luminaires, as well as receptacles installed in new construction must be connected to an equipment grounding conductor. In older non-grounded systems that do not have an equipment grounding conductor at the outlet, a GFCI device is able to provide protection against electric shock when used with replacement luminaires, as well as receptacles.

Exception No. 3 of Section 410.44 and section 406.4(D)(2)(b) and (c) allow the use of a GFCI device to be used instead of an equipment grounding conductor when an equipment grounding conductor is not available at the outlet. Both of these installations refer to the replacement of equipment, and devices on an existing non-grounded or two-wire circuit. Section 410.44 Ex. No. 3 refers to the replacement of a luminaire at a lighting outlet not containing an existing equipment grounding conductor. Section 406.4(D)(2) refers to the replacement of a receptacle, at a receptacle outlet not containing an existing equipment grounding conductor.

The operation of a GFCI device is activated when sensing a difference between the current on the ungrounded conductor and the returning current on the grounded conductor; a difference of .005 amps (5 milliamps) will usually activate a GFCI device. A GFCI device works by opening the circuit when it senses an imbalance of current between the ungrounded conductor and the grounded conductor. In the case of a fault to ground (ground fault) where some of the current is traveling an unknown path to ground, the GFCI will read it as an imbalance and trip the device, thereby opening the circuit and preventing any further current flow.

Without an equipment grounding conductor that returns fault current to the electric source, a fault to ground in a metal luminaire could leave the circuit, as well as the exposed metal of the luminaire energized, making it a serious shock hazard. In older 2-wire systems that do not have this equipment grounding conductor, a GFCI device can provide the same protection, when replacing luminaires and receptacles.

Question 44: Why are replacement luminaires installed on systems without an equipment grounding conductor considered to be protected when supplied by a GFCI protected circuit?

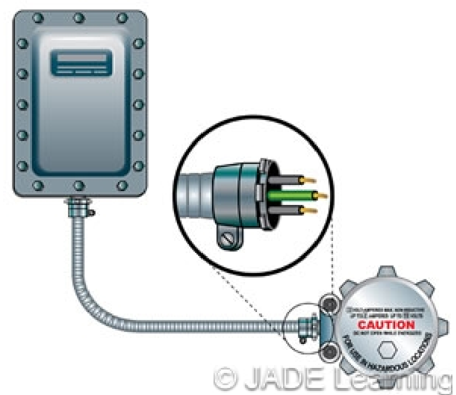
A: The GFCI device creates an equipment grounding conductor and will trip the circuit if it detects a fault.
B: The GFCI device monitors ground-fault current and will trip the circuit if it detects a fault.
C: The GFCI device measures current between the luminaire and ground and will trip the circuit if it detects a fault.
D: The GFCI compares the amount of current between the grounded and ungrounded conductor and will trip the circuit if it detects a fault.

Question 45: 501.30(B) Grounding and Bonding, Class I, Divisions 1 and 2. Types of Equipment Grounding Conductors.

Question ID#: 11085.0

In Class I, Division 1 and 2 locations there is always the danger of an explosion. The flammable vapors that are present in Class I locations can be ignited by the smallest spark.

Generally, if flexible metal conduit (FMC) or liquidtight flexible metal conduit (LFMC) are used in Class I, Division 1 or 2 locations, an equipment bonding jumper of the wire type, in compliance with 250.102, must be used to ensure the continuity between the flexible conduit and enclosures or equipment.



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

Section 250.102 permits the equipment bonding jumper to be installed on the inside or outside of the conduit, and requires the size of the bonding jumper to be selected from Table 250.122.

There are a few exceptions to the requirement to run a wire type equipment bonding jumper when using listed liquidtight flexible metal conduit (LFMC) in Class I, Division 2 locations. However, the bonding jumper ***may be deleted*** if ***all*** of the following are met:

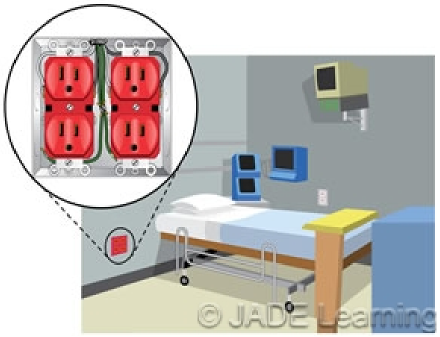
- Fittings listed for grounding are used with listed liquidtight flexible metal conduit measuring 6 feet or less.
- The circuit overcurrent protection is limited to 10 amps or less.
- The load is not a power utilization load.

Question 45: Which of the following statements about grounding and bonding in Class I, Division 1 & 2 locations is correct?

A: FMC is permitted to be used as an equipment bonding conductor in a Class I, Division 1 & 2 location.
B: LFMC is permitted to be used as a wiring method if a bonding jumper is installed.
C: FMC is not permitted to be used in any hazardous location.
D: Both LFMC and FMC are permitted to be used as an equipment bonding conductor in Class I, Division 1 & 2 locations without installing a wire type bonding jumper.

Question 46: 517.13(B) Health Care Facilities. Grounding of Receptacles and Fixed Electrical Equipment in Patient Care Areas. Insulated EGC.

Question ID#: 11086.0



Patient care areas in health care facilities require two types of equipment grounds.

Patient care areas in health care facilities require two types of equipment grounding. The raceway system must be an effective ground-fault return path, and an insulated copper equipment grounding conductor must be installed. This is called redundant grounding.

An insulated copper equipment grounding conductor, either solid or stranded, and sized in accordance with Table 250.122, must be installed with the branch circuit conductors in a wiring method that qualifies as an equipment grounding conductor.

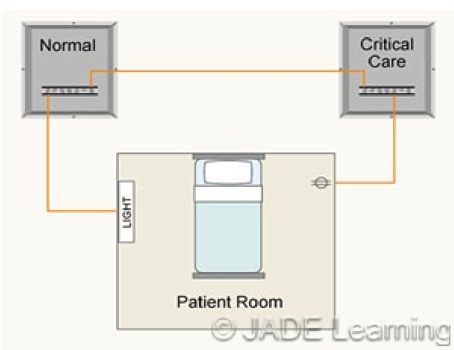
An exception allows luminaires located higher than 7 1/2 feet above the floor and switches located outside of the patient care vicinity to be connected to the metal raceway system without a connection to an insulated equipment grounding conductor.

Question 46: Patient care areas in health care facilities require redundant grounding. Which of the following provides the two types of required grounding?

A: A metal raceway and an insulated copper equipment grounding conductor.
B: A cable having a metallic raceway and a bare copper equipment grounding conductor.
C: An insulated equipment grounding conductor and a bare equipment grounding conductor.
D: A metal raceway and an aluminum equipment grounding conductor.

Question 47: 517.14 Health Care Facilities. Panelboard Bonding.

Question ID#: 11087.0



All panelboards supplying circuits that serve the same patient vicinity are required to be connected together using an insulated copper conductor not smaller than 10 AWG.

The equipment grounding terminal bars of all panelboards supplying circuits that serve the same patient vicinity are required to be connected together using an insulated copper conductor not smaller than No. 10 AWG. The conductor must be continuous from panel to panel but can be broken in order to terminate on the equipment terminal bus in each panelboard. The purpose of bonding two separate panelboards together is to minimize any potential voltage differences between equipment that is supplied from different panelboards.

Branch circuits in patient care areas of health care facilities are supplied from the essential electrical system and the normal system, or from more than one panelboard on a single system. Outlets on these branch circuits are used for medical equipment that is connected to the patient. The effects of an electrical shock are greatly increased when electrical equipment is tied directly to the patient's body. Panelboards are bonded together as a precaution against creating potential differences that could create an electric shock.

Question 47: How are the equipment grounding terminal buses of the normal and essential branch-circuit panelboards serving the same individual patient care vicinity required to be connected together?

A: An insulated continuous copper conductor not smaller than No. 10 AWG.
B: A bare continuous copper conductor not smaller than No. 8 AWG.
C: Rigid metal conduit with threaded couplings.
D: Flexible metal conduit with listed fittings.

Question 48: 600.7 Electric Signs and Outline Lighting. Grounding and Bonding.

Question ID#: 11088.0

Section 600.7 requires non-current-carrying metal parts of signs and outline lighting equipment to be grounded by connection to an equipment grounding conductor. Portable signs which are double insulated are not required to be connected to an equipment grounding conductor.

If the equipment grounding conductor is a wire, it must be sized based on the rating of the overcurrent device protecting the branch circuit and selected from Table 250.122.

Auxiliary grounding electrodes are permitted for electric signs and are connected to the equipment grounding conductor.

Non-current-carrying metal parts of signs and outline lighting are required to be grounded.

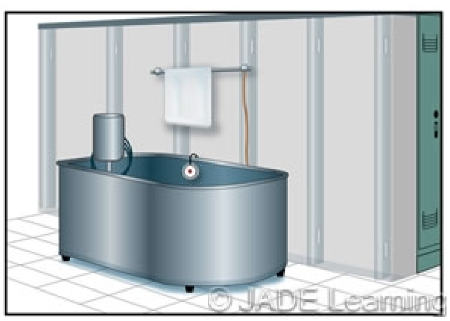
Non-current-carrying metal parts of signs and outline lighting equipment are required to be bonded together. Bonding connections shall be made by listed pressure connectors, terminal bars, machine screw-type fasteners or other listed means. The metal parts of the building cannot be used as a means for bonding metal parts of signs together. Bonding conductors cannot be smaller than No. 14 AWG and must be protected from physical damage.

Question 48: Which of the following is a violation of the bonding or grounding requirements for a metal sign?

A: A metal sign using only incandescent lighting is supplied by a 120 volt, 30 amp circuit installed in RMC; the sign is connected to a No. 10 AWG copper equipment grounding conductor.
B: A portable sign is supplied by a 120 volt, 20 amp circuit that does not include an equipment grounding conductor; the sign is clearly marked double insulated.
C: Each of three separate parts of a sign is connected to the building steel without an equipment bonding jumper connected between the separate parts.
D: An auxiliary grounding electrode is installed at a sign and connected to the equipment grounding conductor.

Question 49: 680.6 Swimming Pools, Fountains, and Similar Installations. Grounding.

Question ID#: 11089.0



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

Because there is an increased risk of electric shock in swimming pools, fountains, hydromassage tubs, spas and similar installations, the NEC requires all electrical equipment to be grounded and bonded in accordance with Article 250.

The following equipment is required to be grounded:

- Underwater luminaires and through-wall lighting assemblies, except for low-voltage lighting products that are listed for use without a grounding conductor.
- Electrical equipment within 5 feet of the inside wall of the body of water.
- All equipment that is associated with recirculating water.
- All junction boxes.
- All power supplies and transformers.
- All ground-fault circuit-interrupters.
- Panelboards that supply power for the equipment.

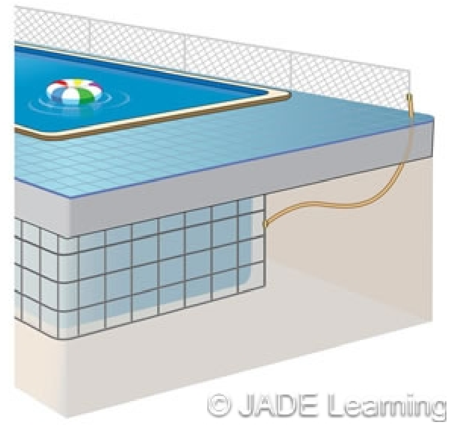
Question 49: Which of the following types of equipment used in a swimming pool is NOT required to be grounded?

A: A 120 volt underwater luminaire.
B: A low-voltage lighting assembly which does not have provisions for grounding.
C: A cord-and-plug connected 230 volt recirculating pump.
D: A power supply for a spa.

Question 50: 680.26 Swimming Pools, Fountains, and Similar Installations. Equipotential Bonding.

Question ID#: 11090.0

As defined in Article 100, bonding means equipment is connected together to establish electrical continuity and conductivity. The function of equipotential bonding is different from the primary function of bonding. Equipment grounding and bonding required by Article 250 provides a path for ground-fault current to travel back to the electric source. The equipotential bonding system around a swimming pool required by 680.26 serves a different purpose.



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

The purpose of the equipotential bonding system and associated bonding conductors around swimming pools is to reduce voltage gradients between conductive surfaces in the pool area. When pool equipment and other conductive surfaces are bonded together, there is less chance of a person getting shocked when in contact with metal equipment, fittings or other conductive surfaces such as a concrete pool deck, or even the pool water.

There is no requirement that the bonding conductors used to reduce voltage gradients in the pool are to be extended to the equipment grounding bar in the pool panelboard, service equipment or associated enclosures. This section only requires that all parts specified in 680.26(B)(1) through (B)(7), such as conductive pools shells and perimeter surfaces, are to be bonded to each other in order to place all equipment on the same equal potential.

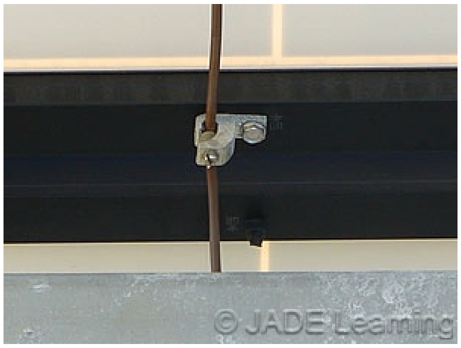
Chemicals used to treat pool water, such as chlorine increase the conductivity of the water so a means must also be provided to ensure that voltage gradients are not present between the pool water and other conductive surfaces. If bonded components, such as an underwater luminaire, are directly in contact with pool water no additional bonding is required. If, however, pool water is not in direct contact with a bonded metal part, 680.26(C) requires a conductive surface to be installed in direct contact with the pool water to create an equipotential bonding connection between the pool water and the equipotential bonding system in the pool area. The conductive surface must be corrosion-resistant and provide at least 9 sq. in. of surface area in direct contact with the pool water. It must be located where not subject to physical damage or dislodgement and connected to the equipotential bonding system with a No. 8 AWG solid copper bonding jumper.

Question 50: Which of the following is NOT a reason for bonding in and around swimming pools?

A: Equipotential bonding reduces voltage gradients in the pool area.
B: Equipotential bonding ensures that all metal parts are at the same electrical potential.
C: Equipotential bonding ensures that a circuit breaker will trip if there is a short circuit in the pump motor.
D: Equipotential bonding reduces possible electric shock hazards.

Question 51: 690.43 Solar Photovoltaic (PV) Systems. Equipment Grounding.

Question ID#: 11091.0



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

All exposed non-current-carrying metal components of Solar Photovoltaic (PV) systems are required to be grounded. Metal PV frames, PV electrical equipment, raceways for conductors, and conductor enclosures must be connected to an equipment grounding conductor. If the solar photovoltaic modules are connected to a metal frame, and the metal frame is connected to an equipment grounding conductor, then the PV modules are considered to be grounded. Listed clips or other devices are used to connect the metal frames of adjacent PV modules and to connect the metal frames of the PV modules to the metal mounting rack.

The equipment grounding conductors for PV arrays and structures are required to be installed in the same cable or raceway with the PV array circuit conductors when the circuit conductors leave the area where the PV array is installed.

Question 51: Which of the following statements about grounding of Solar Photovoltaic systems is correct?

A: Metal structures used to mount PV modules are not part of the equipment grounding system.
B: PV system components are required to be grounded only if the PV array voltage exceeds 50 volts.
C: Equipment grounding conductors for PV arrays are required to be installed in the same raceway with array circuit conductors that leave the vicinity of the PV array.
D: DC system components are not required to be grounded.

Answer Sheet

Darken the correct answer. Sample: A ● C D

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