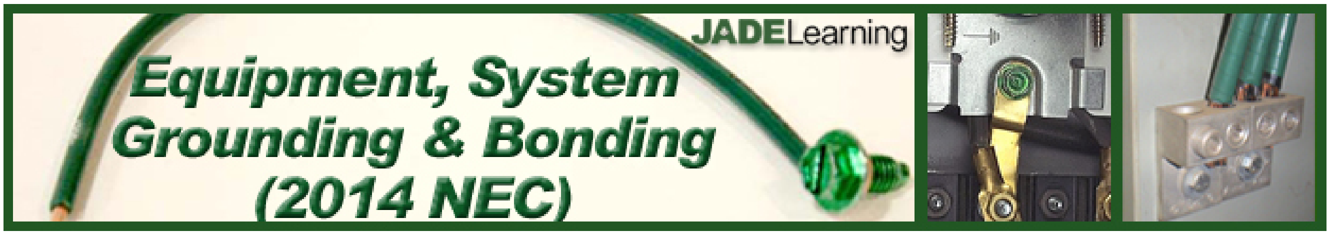


Equipment, System Grounding and Bonding (2014 NEC) (Homestudy)

Idaho 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. This course also covers system grounding and bonding according to the 2014 NEC: grounding and bonding basics, grounding and bonding at services, transformers, and generators.

Course# ID14084   4 Industry Related Credit Hours $55.00

This course is currently approved by the Idaho Electrical Bureau under course number ID14084.

Completion of this continuing education course will satisfy 4.000 credit hours of course credit type 'Industry Related' for Electrical license renewal in the state of Idaho. Course credit type 'Industry Related'. Board issued approval date: 3/7/2014. Board issued expiration date: 6/30/2018.

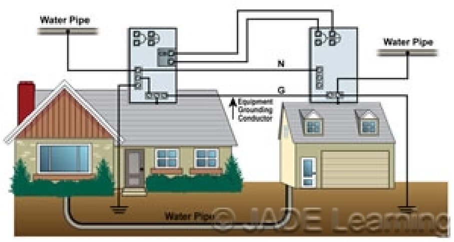
Equipment, System Grounding and Bonding (2014 NEC) (Homestudy) - ID

Equipment Grounding and Bonding

Part I General

Question 1: 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 1: 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: Ground-fault protection for equipment is installed at the service.
B: The wiring method for the feeder is UF cable 6/3 with ground.
C: A grounding electrode conductor is installed at the second building.
D: An equipment grounding conductor is not run with the feeder.

Question 2: 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 2:   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: Only when protected by a wood enclosure when subject to physical damage.
C: When installed without protection when not subject to physical damage.
D: Only when protected by a metal enclosure when subject to physical damage.

Question 3:   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.

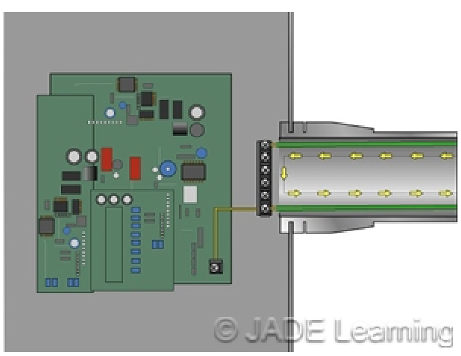
The first 5 feet of metal water pipe above ground is permitted to extend the connection to the grounding electrode (water pipe).

Question 3:   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 second building is supplied by feeders or branch circuits.
D: When the feeder to the second building does not have an equipment grounding conductor.

Question 4:   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 4: 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: Disconnecting the electronic equipment, its raceways, and its enclosure from the electrical system equipment ground and connecting it to a separate earth ground.
C: Changing the locations where the grounding connections are made.
D: Interrupting the continuity of the conductor or conductive path causing the objectionable current.

Question 5: 250.8(B) Connection of Grounding and Bonding Equipment. Methods Not Permitted.

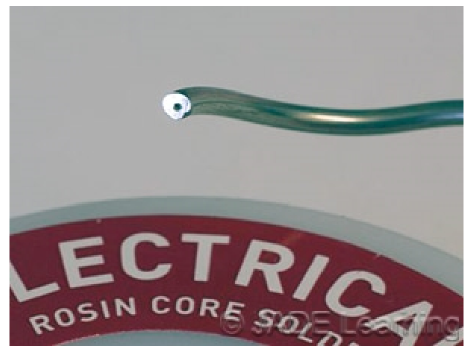
Question ID#: 11039.0

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

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

Question 6: 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 6: Which of the following is described as the connection between two or more portions of the equipment grounding conductor?

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

Question 7: 250.1 Scope.

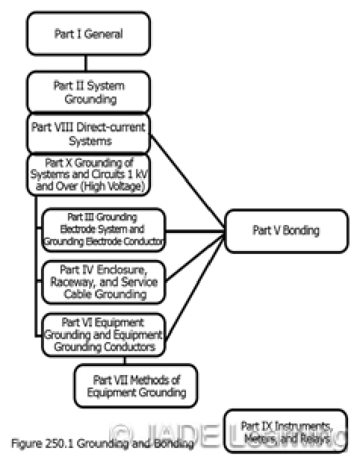
Question ID#: 11037.0

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.

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



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.

Question 7: 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.

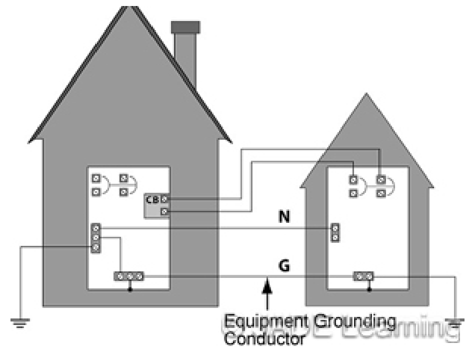
Question 8: 250.32(B)(1) Buildings or Structures Supplied by a Feeder or Branch Circuit. Grounded Systems.

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 8: 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 isolated from the building disconnecting means.
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 connected to the metal enclosure of the building disconnecting means and to the grounding electrode.
D: The equipment grounding conductor is not connected to the grounding electrode at the second building.

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.

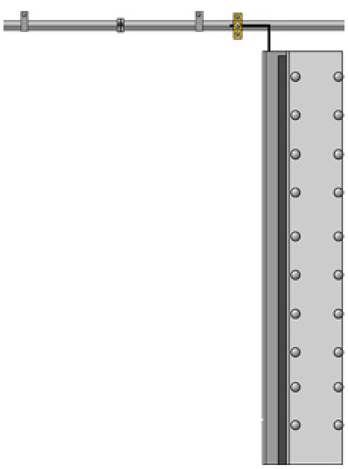
Raceways containing isolated grounding circuits are permitted to be isolated from the enclosures that the raceway is supplying with listed nonmetallic raceway fittings, located at the point of attachment to the enclosure, provided metal enclosures are grounded with an internal insulated equipment grounding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

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

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

Question 10: 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 10: 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 grounded conductor at the service.
C: The service equipment enclosure.
D: The grounding electrode conductor.

Question 11: 250.102(E) Bonding Conductors and Jumpers. Installation.

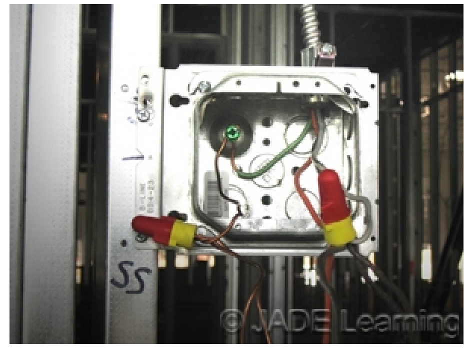
Question ID#: 11048.0

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.



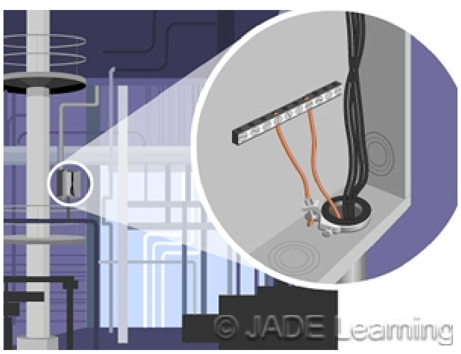
A common way to effectively bond different metallic surfaces of enclosures, electrical equipment, pipes, tubes or structures together is with a copper conductor, rated lugs and appropriate bolts, fasteners or screws.

Question 11: What is the maximum allowable length for an equipment bonding jumper installed on the outside of a raceway?

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

Question 12: 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 12: Why are raceways in hazardous locations bonded together?

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

Question 13: 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:

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

- 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.

Question 13: 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: IMC connected through an eccentric knockout that is not listed to provide a reliable bonding connection.
C: RMC connected with double locknut construction through a correctly sized hole made with a knockout punch.
D: RMC connected to an oversized knockout with reducing washers.

Part VI Equipment Grounding and Equipment Grounding Conductors.

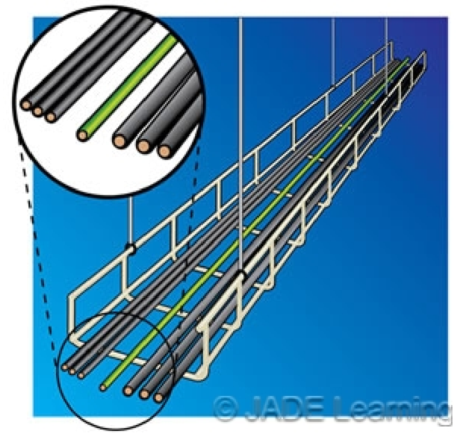
Question 14: 250.122(C) Size of Equipment Grounding Conductors. Multiple Circuits.

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.

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.



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.

Question 14: 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. 6 AWG cu.
B: No. 10 AWG cu.
C: No. 12 AWG cu.
D: No. 8 AWG cu.

Question 15: 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 15: 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: A continuous outer finish that is green.
C: A continuous outer finish that is green with a yellow stripe.
D: Green marking tape at each end.

Question 16: 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.

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

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.

Question 16: Which of the following is a true statement?

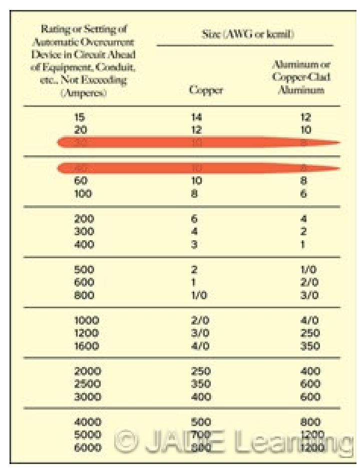
A: Conduit and fittings can be hand-tight if an equipment grounding conductor is installed in the conduit.
B: A socket wrench is required to tighten conduit and fittings.
C: A torque wrench is required to tighten conduit and fittings.
D: Suitable tools must be used to tighten conduit and fittings.

Question 17: 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.



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

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

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.

Question 17: A commercial oven requires a 60 amp branch circuit. What is the minimum size copper equipment grounding conductor?

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

D: No. 8 AWG.

Question 18: 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 18: Which wiring method is NOT recognized as an equipment grounding conductor?

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

Question 19: 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 19: 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: 600 kcmil.
C: 500 kcmil.
D: 700 kcmil.

Question 20: 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 20: 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: Factory authorized technicians can use green tape to identify a black conductor as an equipment grounding conductor in multiconductor cables.
B: 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.
C: Conductors with their insulation stripped away are not permitted as equipment grounding conductors in multiconductor cables.
D: In multiconductor cables, a No. 8 AWG must only be identified by solid green insulation.

Question 21: 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 21: Which of the following bare aluminum equipment grounding conductors is code compliant?

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

Question 22: 250.118(6) Types of Equipment Grounding Conductors. Liquidtight Flexible Metal Conduit.

Question ID#: 11055.0

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.

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.

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 22: 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 4500 watt, 240 volt water heater on a 30 amp circuit supplied through a 3 foot length of LFMC.
C: A 5 HP motor on a 230 volt, 30 amp circuit supplied through a 4 foot length of LFMC.
D: A flood light on a 120 volt, 15 amp circuit supplied through a 3 foot length of LFMC.

Question 23: 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 23: 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 24: 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 24: What is the maximum permitted length of flexible metal conduit when used as an equipment grounding conductor for a 20 amp circuit?

A: 6 ft.
B: 2 ft.
C: 10 ft.
D: 3 ft.

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.

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.

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

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 15%.
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 25%.

Question 26: 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 26: 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: Coffee makers.
D: Refrigerators.

Question 27: 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.

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

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.

Question 27: Which of the following applications permit a conductor with green insulation inside a cable to be used for other than equipment grounding purposes?

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

Part VII Methods of Equipment Grounding

Question 28: 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 28: The connection between the equipment grounding conductors and a metal box shall be made by all of the following except:

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

Question 29: 250.142 Use of Grounded Circuit Conductor for Grounding Equipment.

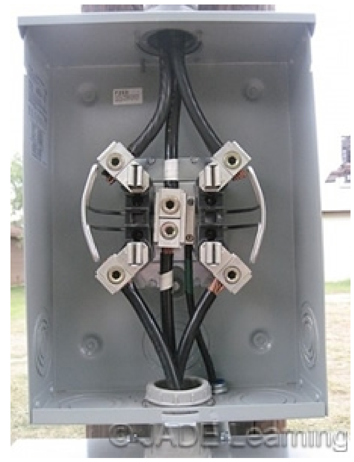
Question ID#: 11071.0

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.

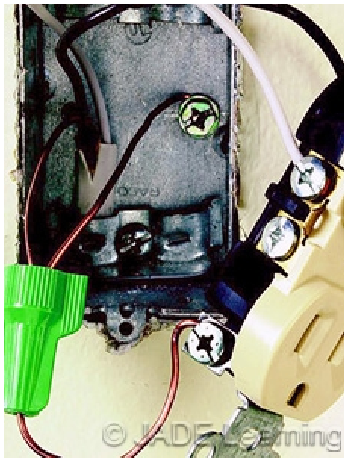
Question 29: Where can a grounded circuit conductor ground non-current-carrying metal parts of equipment?

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

Question 30: 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.



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.

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.

Question 30: 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: Using an insulated equipment grounding conductor to ground receptacles installed in a metal box grounded by a RMC raceway system.
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: 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.

Question 31: 250.130(C) Equipment Grounding Conductor Connections. Nongrounding Receptacle.

Question ID#: 11066.0

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.

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

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

Question 32: 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 32: 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 33: 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 33: 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 bare stranded No. 8 AWG aluminum equipment grounding conductor in type SER cable.
C: A green solid No. 10 AWG copper equipment grounding conductor.
D: A solid white No. 10 AWG copper grounded circuit conductor.

Question 34: 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.

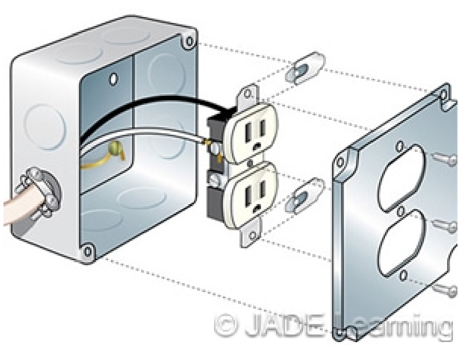
NOTE: The installation described in the exception was the general rule rather than an exception prior to the 1996 NEC. Since 1996, the frames of ranges and clothes dryers have been grounded by connection to an equipment grounding conductor.

Question 34: 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: 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.
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: Using the grounded conductor to ground the frame of an electric range in an existing installation.

Question 35: 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 35: Which of the following statements about bonding receptacles to metal boxes is correct?

A: 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.
B: When isolated receptacles are used, receptacle boxes and raceways are not required to be grounded.
C: 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.
D: A bonding jumper is always required to connect the grounding terminal of a receptacle to the box in which it is installed.

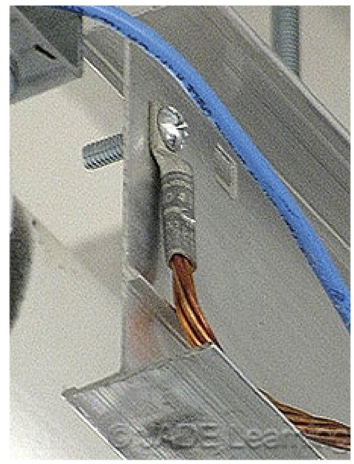
Question 36: 250.136(A) Equipment Considered Grounded. Equipment Secured to Grounded Metal Supports.

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

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

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

Equipment grounding conductors are required for medium voltage circuits.

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.

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

Applications

Question 38: 501.30(B) Grounding and Bonding, Class I, Divisions 1 and 2. Types of Equipment Grounding Conductors.

Question ID#: 11085.0

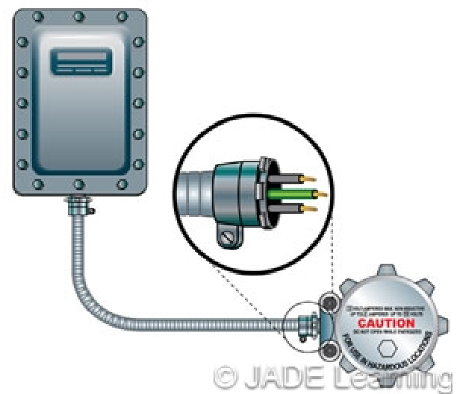
In Class I, Division 1 and 2 locations there is always the danger of an explosion. The flammable vapors that are present in Class I locations can be ignited by the smallest spark.

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.

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.



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

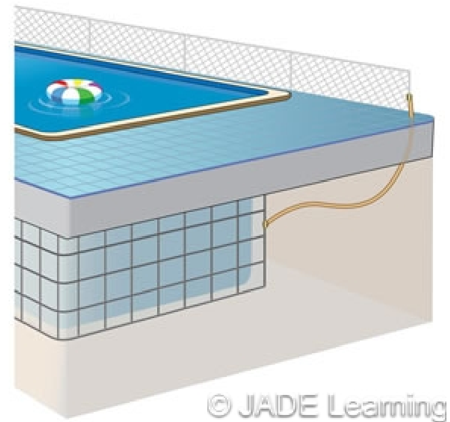
Question 38: Which of the following statements about grounding and bonding in Class I, Division 1 & 2 locations is correct?

A: FMC is not permitted to be used in any hazardous location.
B: 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.
C: LFMC is permitted to be used as a wiring method if a bonding jumper is installed.
D: FMC is permitted to be used as an equipment bonding conductor in a Class I, Division 1 & 2 location.

Question 39: 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 39: Which of the following is NOT a reason for bonding in and around swimming pools?

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

Question 40: 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.

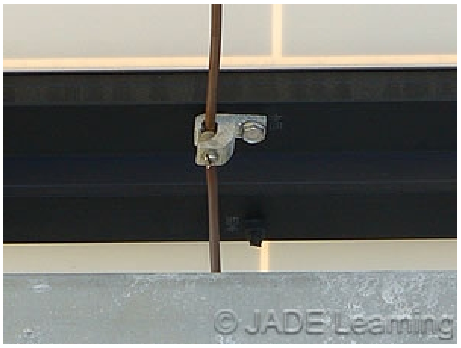
Without an equipment grounding conductor that returns fault current to the electric source, a fault to ground in a metal luminaire could leave the circuit, as well as the exposed metal of the luminaire energized, making it a serious shock hazard. In older 2-wire systems that do not have this equipment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

Question 40: 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 measures current between the luminaire and ground and will trip the circuit if it detects a fault.
C: The GFCI compares the amount of current between the grounded and ungrounded conductor and will trip the circuit if it detects a fault.
D: The GFCI device monitors ground-fault current and will trip the circuit if it detects a fault.

Question 41: 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 41: Which of the following statements about grounding of Solar Photovoltaic systems is correct?

A: 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.
B: DC system components are not required to be grounded.
C: PV system components are required to be grounded only if the PV array voltage exceeds 50 volts.
D: Metal structures used to mount PV modules are not part of the equipment grounding system.

Question 42: 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.

Except as replacements, receptacles installed on 15 and 20 amp 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.

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 42: 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 43: 404.9(B) Provisions for General-Use Snap Switches. Grounding.

Question ID#: 11079.0

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

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

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

Question 44: 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.

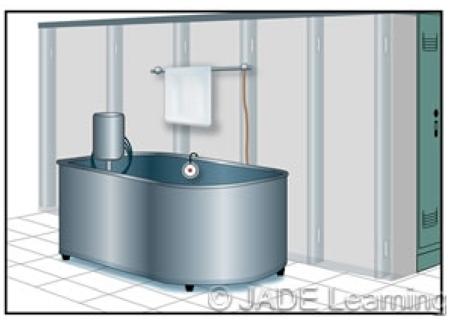
Equipment bonding conductors are permitted to be connected in parallel in single or multiple raceways. When ungrounded conductors are installed in parallel in multiple raceways, equipment bonding conductors are required to be installed in each raceway and connected in parallel at both ends.

Question 44: 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. 1/0 AWG.
B: No. 1 AWG.
C: No. 2/0 AWG.
D: No. 3/0 AWG.

Question 45: 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:

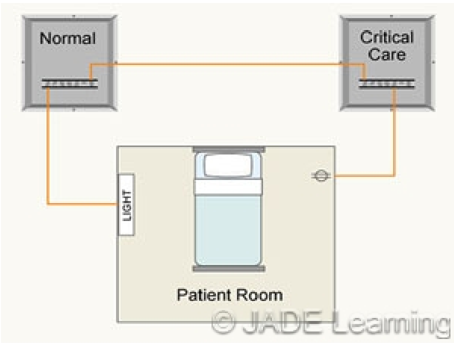
- Underwater luminaires and through-wall lighting assemblies, except for low-voltage lighting products that are listed for use without a grounding conductor.
- Electrical equipment within 5 feet of the inside wall of the body of water.
- All equipment that is associated with recirculating water.
- All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

Question 45: 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 power supply for a spa.
D: A cord-and-plug connected 230 volt recirculating pump.

Question 46: 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 46: 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: Flexible metal conduit with listed fittings.
B: A bare continuous copper conductor not smaller than No. 8 AWG.
C: Rigid metal conduit with threaded couplings.
D: An insulated continuous copper conductor not smaller than No. 10 AWG.

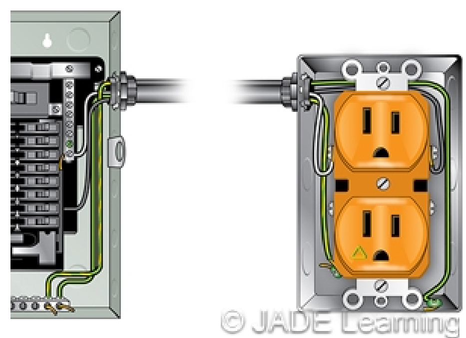
Question 47: 406.3(D) Receptacle Rating and Type. Isolated Ground Receptacles.

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.



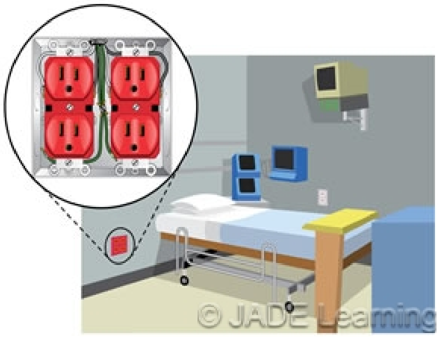
The equipment grounding terminal is required to be grounded by an insulated equipment grounding conductor that is run with the circuit conductors.

Question 47: 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: The equipment grounding conductor that is connected to the isolated ground receptacle must have solid orange insulation.
D: 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.

Question 48: 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 48: Patient care areas in health care facilities require redundant grounding. Which of the following provides the two types of required grounding?

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

Question 49: 410.44 Luminaires, Lampholders, and Lamps. Methods of Grounding.

Question ID#: 11083.0

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.

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.

Question 49: Which of the following statements about the grounding of luminaires is correct?

A: Only luminaires that are supplied by circuits containing an equipment grounding conductor are required to be grounded.
B: All types of luminaires are required to be grounded.
C: 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.
D: Luminaires that include provisions for connection to an equipment grounding conductor are always required to be connected to an equipment grounding conductor.

Question 50: 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.

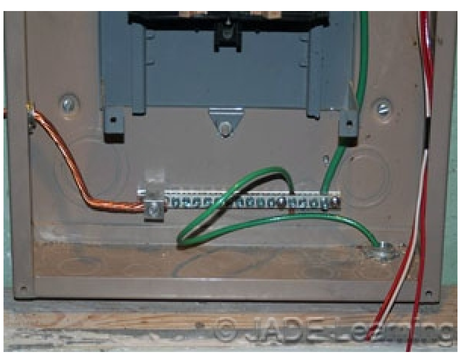
Non-current-carrying metal parts of signs and outline lighting equipment are required to be bonded together. Bonding connections shall be made by listed pressure connectors, terminal bars, machine screw-type fasteners or other listed means. The metal parts of the building cannot be used as a means for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

Question 50: Which of the following is a violation of the bonding or grounding requirements for a metal sign?

A: An auxiliary grounding electrode is installed at a sign and connected to the 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: 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.

Question 51: 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 51: Which of the following statements about a metal panelboard that is not used as service equipment is true?

A: Grounded neutral conductors are bonded to the panelboard.
B: Grounded neutral conductors and equipment grounding conductors are required to be terminated on the equipment grounding terminal bar.
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.

System Grounding and Bonding

Grounding and Bonding Basics

Question 52: 250.4(A)(3)&(4) Bonding of Electrical Equipment. Bonding of Electrically Conductive Materials and Other Equipment.

Question ID#: 10402.0

Electrical equipment, enclosures and conduit are connected together and to the system grounded conductor to establish an effective ground-fault current path.

Bonding electrical equipment, enclosures, raceways, and other equipment that might become energized to the grounded conductor at the supply source establishes an effective ground-fault current path.

Normally non-current carrying metal raceways and enclosures must be bonded together in an unbroken path that leads from the furthest point in the system all the way back to the electrical supply source.

Bonding raceways, enclosures and equipment to form a continuous path is done by making up fittings wrench-tight, scraping away any non-conductive material from connection points, and installing bonding jumpers, bonding bushings and other fittings listed for grounding and bonding.

A single loose fitting or connection can break the ground-fault current path and prevent the overcurrent device from taking the faulted circuit off line.

Question 52: What does "bonding" of electrical equipment mean?

A: Isolating electrical enclosures from ground.
B: Creating a ground-fault current path.
C: Installing insulating fittings on ungrounded terminals.
D: Inspecting electrical connections for overheating.

Question 53: 250.4(A)(1) Grounded Systems. Electrical System Grounding.

Question ID#: 10400.0

Grounded systems are different from ungrounded systems in two important ways:

- Grounded systems limit the voltage imposed by lightning or contact with high voltage lines.
- Grounded systems stabilize the voltage to ground during normal operation.

If a high voltage utility line contacts a service drop conductor, the voltage on the service drop conductor can reach dangerous levels. If the electrical system that is supplied by the service drop conductors is grounded, the voltage will not rise to the level that it would on an ungrounded system.

AC systems are grounded to limit the voltage to ground from lightning strikes and to stabilize the voltage to ground during normal operation.

An Informational Note adds that the grounding and bonding conductors must be as short and straight as possible to be effective in limiting the voltage from lightning and contact with high voltage lines.

The voltage on a grounded system is more stable than the voltage on an ungrounded system. Voltage is always a potential difference between two points. By establishing a ground reference point of zero volts, a grounded system prevents the voltage potential from "floating."

Question 53: In a grounded system:

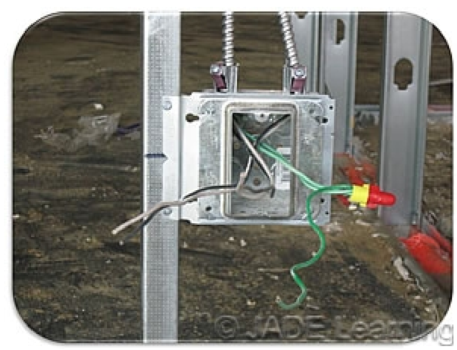
A: Grounding and bonding conductors are coiled to better absorb a lightning strike.
B: The grounding and bonding conductors are isolated from telephone and CATV enclosures.
C: During normal operation the system voltage to earth is stabilized by being grounded.
D: The voltage will never rise above the applied voltage.

Question 54: 250.4(A)(5) Effective Ground-Fault Path.

Question ID#: 10403.0

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

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



Fault current returns to the source on the effective ground-fault current path.

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

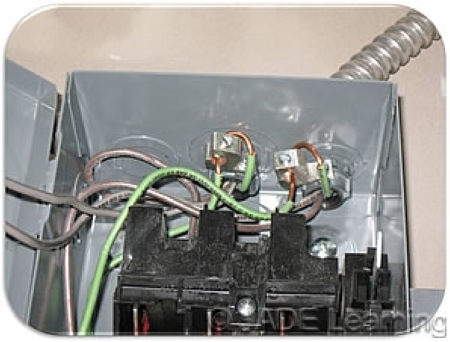
An effective ground-fault current path must be capable of carrying the maximum ground-fault current that it is likely to see. When equipment grounding conductors are sized according to Table 250.122 and grounding electrode conductors are sized according to Table 250.66, they are large enough to carry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

Question 54: What is the purpose of an effective ground-fault path?

A: Provide a path for neutral current on the load side of the service disconnect.
B: Provide a path for normal unbalanced (neutral) current.
C: Provide a low impedance path and be big enough to carry available fault current.
D: Provide a means to test fault current.

Question 55: 250.4(A)(2) Grounded Systems. Grounding of Electrical Equipment.

Question ID#: 10401.0



Enclosures and conduit are grounded to limit the voltage to ground in case they become energized.

Metal enclosures, raceways, and equipment that contain electrical conductors must be connected to earth to limit the voltage to ground.

If the insulation on a conductor fails, the raceway or enclosure can become energized. Grounding equipment enclosures and raceways will limit the voltage rise if they become energized under ground- fault conditions.

It is important to note that connecting metal equipment or raceways to ground does not by itself provide the necessary safety. Bonding raceways and enclosures together, and to the grounded conductor, is what creates an effective ground-fault path that can de-energize the faulted circuit.

Question 55: What does the "grounding" of electrical equipment mean?

A: Installing bonding bushings on conduit.
B: Connecting equipment, enclosures and raceways to the earth.
C: Connecting equipment to the grounded neutral conductor downstream (on the load side) of the service.
D: Adding an additional grounding electrode at the equipment.

Question 56: 250.4 General Requirements for Grounding and Bonding.

Question ID#: 10399.0

Performance requirement: An effective ground-fault current path will cause the circuit breaker to trip. Prescriptive requirement: System bonding jumpers are sized per Table 250.102(C)(1).

This is the most important section in all of Article 250. It is the theory of grounding and bonding at its best and clearest. The rest of Article 250 describes the how-to of grounding and bonding. Section 250.4 describes why we ground equipment and enclosures and bond electrical systems. Section 250.4 describes the purpose of grounding and bonding and why it is important. There are two types of requirements in Article 250:

- [u]Performance requirements[/u] are general statements that explain what grounding and bonding should accomplish.

- [u]Prescriptive requirements[/u] list how to do it.

For example, saying that non-current-carrying conductive material which is part of electrical equipment must be connected together is a performance requirement. Saying that metal enclosures and raceways for other than service conductors shall be connected to the equipment grounding conductor (250.86) is a prescriptive requirement.

Question 56: Which of the following is a performance requirement?

A: The grounding electrode conductor shall be sized from Table 250.66.
B: Non-conductive coatings shall be removed from threads and other contact surfaces.
C: A low impedance ground-fault path shall be installed to facilitate the operation of the overcurrent device.
D: The grounded conductor shall be routed with the phase conductors.

Grounding & Bonding At Services

Question 57: 250.94 Bonding for Other Systems.

Question ID#: 10432.0

Telephone, Cable TV, and other limited energy systems must be bonded to the electrical grounding system at the service. An intersystem bonding termination which is accessible and external to the service equipment must be provided to make the bonding connections from these systems to the electrical grounding grid. If there are other buildings or structures which are fed from the main building, a grounding means must be available there also.

An intersystem bonding termination for grounding other systems is required.

The intersystem bonding termination must have connections for at least 3 intersystem bonding conductors. The intersystem bonding device cannot interfere with opening a service or meter enclosure.

The preferred intersystem bonding method is a device which clamps onto the grounding electrode conductor and provides the required number of bonding connections. Other devices, such as bonding bars which connect to the service equipment enclosures, are also permitted.

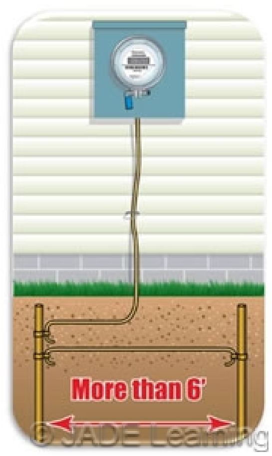
Question 57: Which of the following statements about intersystem bonding is correct?

A: Limited energy systems are bonded to the grounding electrode system at the service.
B: The intersystem bonding device is provided by the telephone company.
C: Limited energy systems must be isolated from the grounding electrode system.
D: A detached garage with electric power and a Cable TV connection does not require an intersystem bonding device.

Question 58: 250.53(A)(2) Ex. Rod, Pipe, and Plate Electrodes. Supplemental Electrode Required.

Question ID#: 10425.0

If a single rod, pipe or plate electrode does not have a resistance to ground of 25 ohms, it shall be supplemented by an additional electrode such as the metal frame of the building, a concrete encased electrode, a ground ring, or a second rod, pipe or plate. All the grounding electrodes must be bonded together. The NEC does not specify the required resistance to ground of the supplemental electrode; it simply requires that a supplemental electrode be installed and bonded to the original electrode. The NEC does not require that the two electrodes bonded together have a 25-ohms to ground (or lower) resistance.



If the resistance to ground for a ground rod is more than 25 ohms, a second rod must be installed at least 6 ft. away from the first ground rod.

According to the exception, if a single rod, pipe, or plate grounding electrode has a resistance to earth of 25 ohms or less, the supplemental electrode shall not be required.

Installing an additional electrode to the rod, pipe or plate electrode will lower the total resistance to ground of the grounding electrode system.

A low resistance connection to a ground rod or plate is important for the same reason a low resistance is desirable for any grounding electrode. A low resistance grounding electrode will limit the voltage to ground on raceways and enclosures when there is a ground fault, or if the building is struck by lightning.

Question 58: The measured resistance of a single driven ground rod is 60 ohms. What is required?

A: Drive a second ground rod and bond it to the first rod.
B: Attach an extension to the ground rod and drive it deeper than 8 ft.
C: Increase the size of the grounding electrode conductor.
D: Drive additional ground rods until the total resistance is less than 25 ohms.

Question 59: 250.52(A)(4)-(8) Ground Ring; Rod and Pipe Electrodes; Plate Electrodes; Other Local Metal Underground Systems or Structures.

Question ID#: 10423.0

Other electrodes that are permitted for grounding include: ground rings, rod and pipe electrodes, plate electrodes and metal underground structures that are not bonded to a metal water pipe.

Ground rods, rings, plates, and local underground systems are permitted to be used as grounding electrodes.

Ground rings are usually used on commercial buildings with large amounts of communication and computer gear. The minimum requirement for a ground ring is that it must encircle the building, be in direct contact with the earth, have at least 20 ft. of bare copper, and be a minimum of a No. 2 AWG. Most ground rings use considerably larger wire. A 3/0 AWG ground ring is not uncommon.

Rod and pipe electrodes must be at least 8 ft. in length. Copper or zinc coated steel rods must be at least 5/8 inch in diameter.

Plate electrodes are not common, but when used must have at least 2 square ft. of area exposed to the earth. Steel and iron plates must be at least 1/4 inch thick.

Other local metal underground systems or structures include underground piping systems, underground tanks, and underground metal well casings that are not bonded to a metal water pipe.

Section 250.52(B) lists two structures that are ***not*** permitted to be used for grounding electrodes:

- Underground metal gas pipe systems
- Any underground Aluminum material

Question 59: Which of the following is an acceptable grounding electrode?

A: A 100 ft. ground ring using a No. 1 AWG bare cu. conductor.
B: An 8 ft., 1/2 inch, unlisted copper ground rod.
C: 20 ft. of underground gas piping.
D: A .5 ft. x .5 ft. square steel plate.

Question 60: 250.64(D)(3) Service with Multiple Disconnecting Means Enclosures. Common Location.

Question ID#: 10429.0

A single grounding electrode conductor can be installed which will ground the entire service. The size is selected from Table 250.66 based on the size of the service entrance conductors.

This is the 3rd of 3 ways to make a connection to the grounding electrode when a service has more than 1 service disconnecting means enclosure.

A single grounding electrode conductor can be installed from the service equipment to a grounding electrode. The size of the single grounding electrode is selected from Table 250.66 and is based on the area of the largest ungrounded service entrance conductor. If the ungrounded conductors are installed in parallel, the sum of the equivalent areas of the paralleled ungrounded conductors is used. The grounding electrode conductor never is required to be larger than 3/0 cu.

The size of the grounding electrode conductor taps are also selected from Table 250.66, but are based on the size of the service entrance conductors supplying the individual service disconnect enclosure.

Question 60: If a service is fed with three parallel runs of 500 kcmil copper, what is the minimum size of the grounding electrode conductor run to the grounded steel frame of a building?

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

Question 61: 250.24 Grounding Service-Supplied Alternating-Current Systems.

Question ID#: 10407.0

The grounding electrode conductor is connected between the load end of the service drop or lateral up to the service disconnecting means.

One end of the grounding electrode conductor is connected to the grounding electrode. The other end of the grounding electrode conductor shall be connected to the grounded conductor at the load end of the service drop or service lateral, in the meter enclosure, or at the service disconnecting means.

The connection between the grounding electrode conductor and the grounded service conductor must be accessible. A connection between the grounding electrode conductor and the grounded conductor shall not be made on the load side of the service disconnecting means.

Question 61: Which of the following is a permitted location to connect the grounding electrode conductor?

A: To an ungrounded conductor in the service equipment.
B: To the equipment grounding conductor terminal in a sub-panel.
C: To the grounded conductor terminal in the main service disconnecting means.
D: To the grounded conductor terminal in a sub-panel.

Question 62: 250.64(D)(1) Service with Multiple Disconnecting Means Enclosures. Grounding Electrode Conductor Taps.

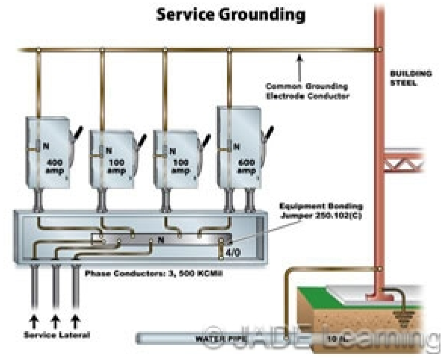
Question ID#: 10427.0

This is 1 of the 3 ways to make a connection to the grounding electrode when a service has more than 1 disconnecting means enclosure.

In this method taps from each service disconnect enclosure are connected to a common grounding electrode conductor that is connected to the grounding electrode. The grounding electrode is usually effectively grounded building steel or a grounded metal water line.

Table 250.66 is used to size the common grounding electrode conductor, based on the size of the largest service entrance conductor, or the sum of the area of paralleled conductors, for the entire service. The size of the grounding electrode conductor taps are also selected from Table 250.66, but are based on the size of the service conductors supplying each service disconnect enclosure.

The tap conductors must be connected to the common grounding electrode conductor with connectors listed as grounding and bonding equipment, or by exothermic welding. The common grounding electrode conductor cannot be spliced.



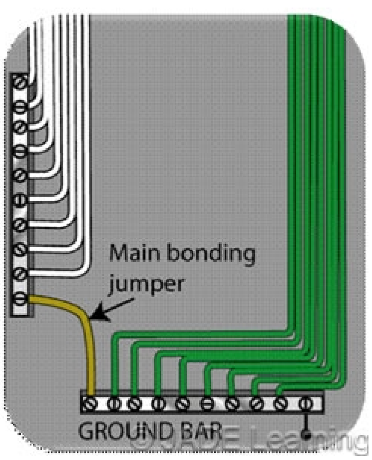
Grounding electrode conductor taps from each enclosure can be made to a common grounding electrode conductor.

Question 62: A service consists of two, 200 amp main service disconnects mounted on a wireway. Each disconnect is fed with 3/0 THHW copper conductors. What size grounding electrode conductor tap is required from each of the 200 amp service disconnects to the common grounding electrode conductor that is connected to a grounded metal water line?

A: No. 1 cu.
B: No. 4 cu.
C: No. 6 cu.
D: No. 2 cu.

Question 63: 250.28 Main Bonding Jumper and System Bonding Jumper.

Question ID#: 10416.0



The main bonding jumper is installed at the service. The system bonding jumper is installed at a separately derived system.

The function of the system bonding jumper is similar to that of the main bonding jumper. Both connect the equipment grounding conductor to the grounded circuit conductor. The main bonding jumper makes this connection at the service. The system bonding jumper makes the connection at a separately derived system.

The main bonding jumper connects the equipment grounding conductors and the service disconnect enclosures to the grounded conductor. The grounding electrode conductor connects the equipment grounding conductors and the service enclosures to the earth.

The main bonding jumper is the bridge to the grounded conductor from every equipment grounding conductor in the system. If there are no transformers downstream from the service, then any ground-fault on the system will arrive at the main bonding jumper at the service.

Fault current always returns to the electrical source over the service neutral or the separately derived grounded neutral. The main bonding jumper is how fault-current coming back to the service on the equipment grounds gets over to the service neutral. If the main bonding jumper is not installed, the only way fault-current can get back to the utility transformer is through the earth, and that is a very high resistance path.

If the main bonding jumper is a screw, it must be a green screw with the green screw head visible after installation.

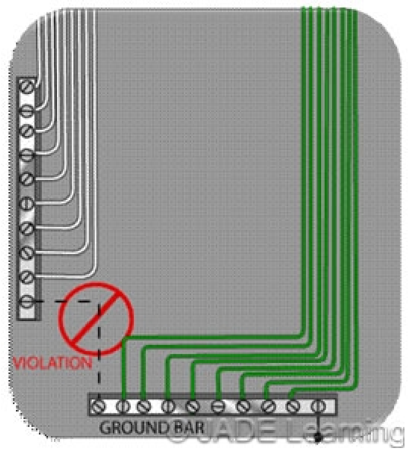
Question 63: The main bonding jumper connects:

A: The grounding electrode conductor to the grounded (neutral) conductor at a subpanel.
B: The equipment grounding conductors to the service-equipment enclosure.
C: The service enclosure to the equipment grounding conductors.
D: The equipment grounding conductors and the service disconnect enclosures to the grounded service conductor at the service.

Question 64: 250.24(A)(5) Grounding Service-Supplied Alternating-Current Systems. Load-Side Grounding Connections.

Question ID#: 10410.0

250.24(A)(5): ***A grounded conductor shall not be connected to normally non-current-carrying metal parts of equipment, to equipment grounding conductor(s), or be reconnected to ground on the load side of the service disconnecting means except as otherwise permitted in this article.***



The grounded conductor cannot be reconnected to ground on the load side of the service disconnecting means.

Some electricians think if a little grounding is good, then more grounding is better. According to this section, grounding the neutral at the service is the only place where the neutral can be connected to ground. At every location after the service disconnecting means, the neutral and equipment grounding conductors must be separated. The grounded (neutral) conductor cannot be connected to the enclosure on the load side of the service but must be insulated from ground.

Only in existing installations can the grounded conductor be connected to normally non-current-carrying metal parts of equipment, such as with existing ranges and clothes dryers.

In new installations an equipment grounding conductor must be included in the circuit to ground equipment and enclosures. The equipment grounding conductor carries fault current back to the electrical source under ground-fault conditions. The grounded conductor carries neutral and unbalanced current. The National Electrical Code wants to keep these 2 different types of current separate.

Question 64: Which of the following installations is a code violation?

A: Using an equipment grounding conductor to ground the frame of a dryer in a new installation.
B: Leaving the grounded conductor bonded to the metal frame of an existing range.
C: Bonding the grounded conductor to the enclosure in a sub-panel.
D: Connecting the grounded conductor to the equipment grounds at the service.

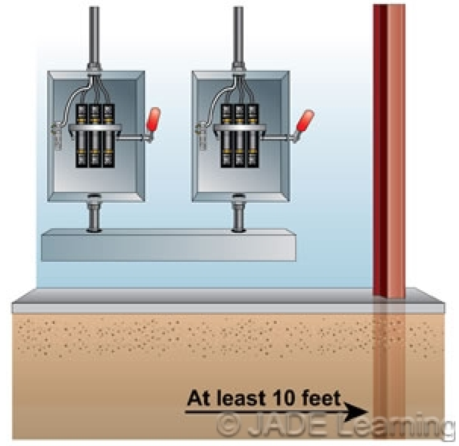
Question 65: 250.64(D)(2) Service with Multiple Disconnecting Means Enclosures.

Question ID#: 10428.0

This is the 2nd of 3 ways to make a connection to the grounding electrode when a service has more than 1 service disconnecting means enclosure.

An individual grounding electrode conductor is permitted to be installed from each separate service disconnect to the grounding electrode. In commercial applications the grounding electrode is most often effectively grounded building steel or a grounded metal water line. In residential applications the grounding electrode conductors are usually connected to a ground rod.

The size of the grounding electrode conductor from each service disconnecting means is sized according to table 250.66, based on the size of the largest ungrounded service conductor that supplies the individual service disconnect.



An individual grounding electrode conductor can be installed from each enclosure to the grounding electrode system.

Question 65: A service with multiple service disconnect enclosures has a 400 amp service disconnect and two 200 amp service disconnects mounted on a wireway. The 400 amp disconnect is fed with 500 kcmil copper and the two 200 amp disconnects are fed with 3/0 copper. What size grounding electrode conductor is required from each service disconnect to the grounded steel frame of the building?

A: 400 amp disconnect - 2/0 cu / 200 amp disconnects No.6 cu.
B: 400 amp disconnect - 1/0 cu. / 200 amp disconnects No.4 cu.
C: 400 amp disconnect - 2/0 cu. / 200 amp disconnects No.4 cu.
D: 400 amp disconnect - 1/0 cu. / 200 amp disconnects No.6 cu.

Question 66: 250.24(D) Grounding Electrode Conductor.

Question ID#: 10415.0

250.24(D): ***A grounding electrode conductor shall be used to connect the equipment grounding conductors, the service-equipment enclosures, and, where the system is grounded, the grounded service conductor to the grounding electrode(s) required by Part III of this article. This conductor shall be sized in accordance with 250.66.***

The grounding electrode conductor is sized from Table 250.66.

On one end the grounding electrode conductor connects to the grounding electrode. On the other end the grounding electrode conductor ties together the equipment grounding conductors, the service-equipment enclosures and the grounded service conductor. The grounding electrode conductor connects the equipment grounding conductors, the service-equipment enclosures and the grounded conductor to earth. The earth is assumed to be at zero volts. Even though the earth is considered a conductor it does not have any voltage potential. Any object connected to earth is forced to take on the voltage potential of earth, zero volts.

Because on one end the grounding electrode conductor is connected to earth, everything on the other end is also connected to earth. The equipment grounding conductors and all the metal parts of the electrical system will be reduced as close as practicable to zero volts. Ideally, the service-equipment enclosures will be at zero volts and the grounded neutral conductor will be at zero volts, measured to ground.

The purpose of the grounding electrode conductor is to keep zero volts potential on electrical enclosures and the grounded neutral. The purpose of the grounding electrode conductor is not to provide a path for fault current returning to the electrical source.

If metal electrical enclosures are at earth potential, then no current can flow from the enclosures through a person's body to ground.

Question 66: A grounding electrode conductor:

A: Is never required for ungrounded AC services.
B: Is not used for high impedance grounded systems.
C: Is only required for grounded AC systems.
D: When required, connects the grounding electrode to service equipment.

Question 67: Table 250.66 Size of Alternating-Current Grounding Electrode Conductor.

Question ID#: 10430.0

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

The purpose of the grounding electrode and the grounding electrode conductor is to limit the voltage to ground if the building is hit by lightning and to provide a ground reference of zero volts for all the electrical conduit and enclosures.

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

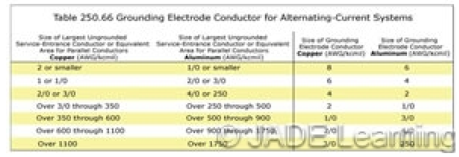


Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors Copper (AWG/kcmil)	Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors Aluminum (AWG/kcmil)	Size of Grounding Electrode Conductor Copper (AWG/kcmil)	Size of Grounding Electrode Conductor Aluminum (AWG/kcmil)
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	[illegible]
Over 1100	Over 1750	3/0	250

The maximum required size for a grounding electrode conductor to a ground rod is No. 6 AWG. The maximum required size to a concrete-encased electrode is No. 4 AWG.

Question 67: What is the minimum size copper grounding electrode conductor for 500 kcmil copper ungrounded service entrance conductors?

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

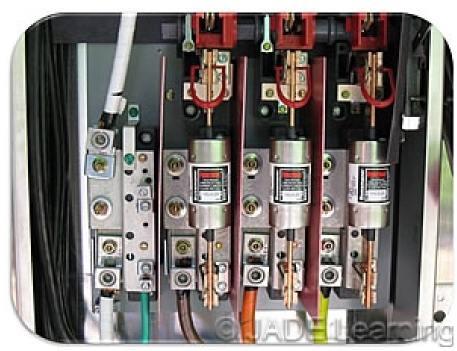
Question 68: 250.24 (A) Grounding Service-Supplied Alternating-Current Systems. System Grounding Connections.

Question ID#: 10406.0

Every building that is supplied by a grounded AC service must have a grounding electrode. A grounding electrode conductor connects the grounding electrode to the grounded service conductor.

The connection from the grounded conductor at the service to the grounding electrode will limit the voltage to ground if the service conductors are hit by lightning or come in accidental contact with high voltage wires. The connection to the grounding electrode will also stabilize the voltage to ground throughout the building wiring system.

A grounded AC service requires a grounding electrode. Since the grounding electrode is in contact with the earth, and the grounding electrode conductor is connected to the service grounded conductor, the building AC service has a direct physical connection with the earth.



A grounding electrode conductor must be connected to the grounded service conductor at each service.

Question 68: Which of the following conductors is used to ground a service-supplied alternating-current system?

A: The equipment grounding conductor in a main distribution panel.
B: The ungrounded conductor in a sub-panel feeder.
C: The grounding electrode conductor in a service enclosure.
D: The grounded conductor in a multiwire branch circuit.

Question 69: 250.24(B) Main Bonding Jumper.

Question ID#: 10411.0

The main bonding jumper connects the equipment grounding conductors to the grounded conductors in the service enclosure.

For grounded systems, the purpose of the main bonding jumper is to connect the equipment grounding conductors and the service-disconnect enclosure to the grounded (neutral) service conductor within each service enclosure.

The main bonding jumper is required by section 250.24(B) to be un-spliced. A conductor that is spliced has more resistance than an un-spliced conductor. The main bonding jumper is part of the low-impedance path for ground-fault current and the impedance (resistance) must be kept as low as possible.

Main bonding jumpers are permitted to be a wire, busbar, or screw as listed in 250.28.

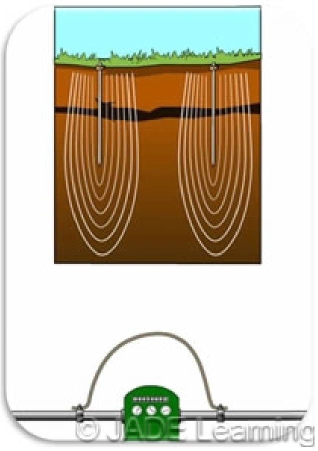
Exception No. 1 says that where more than one service disconnecting means is located in an assembly listed for use as service equipment, only a single main bonding jumper is required that connects the grounded conductor to the assembly enclosure.

Question 69: Which of the following statements about the main bonding jumper is true?

A: If the service equipment is assembled in the field and has multiple disconnecting means, each disconnect enclosure must have a main bonding jumper.
B: In a single UL listed switchgear assembly that has multiple disconnecting means and is listed for use as service equipment, a main bonding jumper must be installed in each disconnecting means.
C: The main bonding jumper can be spliced if irreversible fittings are used.
D: The main bonding jumper isolates the grounded conductor from the service enclosure(s).

Question 70: 250.53 Grounding Electrode Installation.

Question ID#: 10424.0



Grounding electrodes such as ground rods must be spaced at least 6 ft. apart.

There are a number of requirements in this section about how to install the grounding electrode system:

When 2 ground rods or ground plates are installed, they must be at least 6 ft. apart and bonded together.

Bonding jumpers that connect grounding electrodes are bonding jumpers, not grounding electrode conductors. Grounding electrode conductors must be continuous. Bonding jumpers used to connect grounding electrodes together are not required to be continuous.

When metal water pipe is used as a grounding electrode, bonding jumpers must be installed around water meters and water filters. An additional grounding electrode in addition to the metal underground water pipe must be installed to supplement the water pipe.

If the supplemental electrode is a rod, pipe or plate, the grounding electrode conductor which connects to it does not have to be larger than No. 6 AWG.

A driven ground rod must be buried at least 8 ft. in the ground. With an 8 ft. ground rod, the connection to the grounding electrode conductor must be made flush with the ground or below ground. If bedrock is hit when driving the rod, it may be installed at a 45 degree angle. When driving the rod at a 45 degree angle, if bedrock still prevents the rod from being driven, the ground rod may be buried in a trench which is at least 30 inches deep.

Question 70: Which of the following statements is true?

A: Ground rods used as electrodes must be at least 8 ft. apart.
B: A ground plate used as a supplemental grounding electrode must be connected to the grounding electrode system with a minimum No. 4 AWG conductor.
C: Bonding jumpers that connect grounding electrodes are not required to be continuous.
D: Ground rods must be driven straight into the ground.

Question 71: 250.92(A)&(B) Bonding of Services. Method of Bonding at the Service.

Question ID#: 10431.0

Raceways, enclosures, and equipment are bonded to the grounded conductor.

All of the non-current-carrying metal parts of the service equipment must be bonded together. That includes the service raceways, service cable armor, service equipment enclosures, gutters, and meter enclosures.

Electrical continuity between the metal parts of the service is accomplished by (1) Bonding service equipment to the grounded neutral conductor; (2) Connecting service raceways to service equipment enclosures with threaded couplings or threaded bosses made up wrenchtight; (3) Connecting service raceways and metal-clad cable to enclosures with threadless couplings and connectors made up wrenchtight; (4) Using bonding-type locknuts and bushings on service raceways.

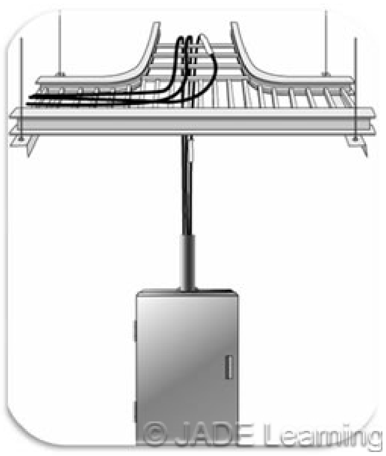
Bonding jumpers are required on raceways which enter service enclosures through concentric or eccentric knockouts on service enclosures. The knockouts punched for larger sized conduit than what is actually used are usually held in place by only a small strip of metal which is not adequate to bond the conduit to the enclosure. Standard locknuts and bushings shall not be the only means for the bonding required by this section but shall be permitted to be installed to make a mechanical connection of the raceway(s).

Question 71: Which of the following statements about bonding service raceways is correct?

A: At the service, bonding bushings are not necessary if threaded conduit is screwed wrenchtight into a threaded hub.
B: Double locknuts can be used to bond service raceways to service enclosures when the raceways are installed through concentric knockouts.
C: The grounded neutral must be isolated from the metal service equipment.
D: EMT can be bonded to service equipment with threadless couplings and locknuts when installed through concentric knockouts.

Question 72: 250.24(C)(1) Routing and Sizing.

Question ID#: 10413.0



When installed with ungrounded service conductors the size of the grounded conductor is selected from Table 250.102(C)(1).

The grounded conductor brought to service equipment must be routed with the phase conductors and is selected from Table 250.102(C)(1).

The grounded conductor must be routed with the phase conductors because if the neutral conductor is not physically installed with the phase conductors, the AC impedance (resistance) of the circuit is higher than if they are installed in the same conduit or cabled together. Since the neutral must carry fault-current, the lower the resistance the better.

The size of the neutral conductor must satisfy two conditions:

- It must be large enough to carry the neutral load, as calculated in Article 220.
- It must be selected from Table 250.102(C)(1), based on the size of the largest ungrounded conductor or equivalent area for parallel conductors.

There is a further requirement for the size of the grounded conductor. For large services where the ungrounded service conductors are larger than 1100 kcmil, the grounded neutral conductor must be at least 12.5 % of the area of the ungrounded conductors. The kcmil area of conductors is given in Chapter 9, Table 8 (Properties of Conductors).

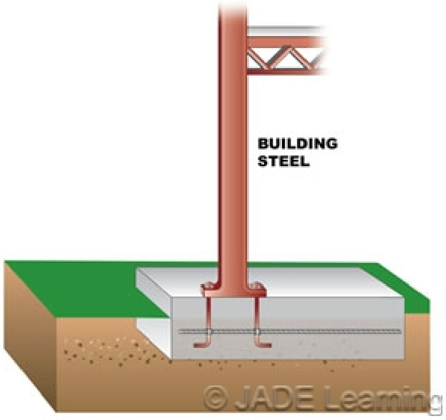
For example: three 500 kcmil conductors are installed in parallel. What is the minimum size for the grounded neutral conductor? Answer: The equivalent size service conductor is 1500 kcmil. Convert to mils to make the math easier = 1,500,000 mils. 1,500,000 mils x 12.5% (.125) = 187,500 mils. From Table 8, the neutral must be equal to or larger than 187,000 mils or size 4/0.

Question 72: What is the minimum size cu. grounded neutral conductor for a service which uses 2/0 cu. ungrounded conductors?

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

Question 73: 250.52(A)(2) Metal Frame of Building or Structure.

Question ID#: 10421.0



In order to be used as a grounding electrode, the metal frame of the building must be connected to earth.

The metal frame of a building is not a grounding electrode unless at least 10 ft. of a metal structural member is in contact with the earth, or the hold-down bolts of a steel column are connected to a concrete-encased electrode (rebar). The connection from the hold-down bolts to the concrete-encased electrode can be by welding, exothermic welding or using steel tie down wires.

Installing a driven ground rod with a No. 6 cu. conductor from the ground rod to the building steel is not a permitted method of connecting the building steel to earth.

Some buildings have structural members that are made from reinforced concrete, rather than steel. The frame of such a building could not be used as a grounding electrode because there is no direct contact between a metal frame and the earth.

Question 73: The metal frame of a building is considered a grounding electrode if:

A: At least 10 ft. of a single structural metal member is in direct contact with the earth.
B: The anchor bolts for a vertical column are embedded in concrete.
C: A structural member is in contact with the earth for 8 ft.
D: The vertical and horizontal framing members are securely fastened together.

Question 74: 250.28(D) Size.

Question ID#: 10417.0

If the main bonding jumper is a screw, strap or bus provided by the manufacturer, the size does not need to be calculated in the field. The manufacturer has already done the calculation to get a listing from a testing agency.

If the main bonding jumper is a wire installed in the field, it is sized from Table 250.102(C)(1), based on the size of the largest service entrance conductor, or the equivalent area of paralleled service conductors.

For example, if the service entrance conductors are 3/0 cu., Table 250.102(C)(1) requires a No. 4 cu. main bonding jumper.

If the service entrance conductors are larger than 1100 kcmil cu. or 1750 kcmil aluminum (the largest size given in Table 250.102(C)(1), according to the Notes, the main bonding jumper must have an area at least 12.5% as large as the service entrance conductors.

For example, if the service entrance conductors have a total area of 2000 kcmil, then the main bonding jumper must have an area at least 12.5% of 2000 kcmil. Step 1: convert from kcmil to mil. 2000 kcmil = 2,000,000 mil. Step 2: multiply by .125. 2,000,000 mil x .125 = 250,000 mil, or 250 kcmil.

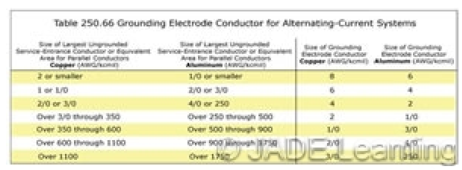


Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors **Copper** (AWG/kcmil)	Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors **Aluminum** (AWG/kcmil)	Size of Grounding Electrode Conductor **Copper** (AWG/kcmil)	Size of Grounding Electrode Conductor **Aluminum** (AWG/kcmil)
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	3/0	250

For main and system bonding jumpers larger than sizes listed in Table 250.102(C)(1), the 12.5% rule applies.

Question 74: What size main bonding jumper is required for 500 kcmil cu. service entrance conductors?

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

Question 75: 250.64 Grounding Electrode Conductor Installation.

Question ID#: 10426.0

No. 4 AWG or larger grounding electrode conductors are only required to have protection if subject to physical damage.

Grounding electrode conductors must be securely fastened to the building or structure. A No. 4 AWG or larger grounding electrode conductor must be protected if it is exposed to physical damage. A No. 6 AWG grounding electrode conductor is not required to be protected if it is not exposed to physical damage.

- Grounding electrode conductors must be installed in one continuous length without a splice, unless:
The splice is made with an irreversible compression-type connector listed for grounding and bonding.
- The splice is made by exothermic welding.
- The grounding electrode conductor is made up of busbars which are connected together to form a single conductor.

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

Question 75: A No. 4 AWG cu. grounding electrode conductor is installed without a raceway in an alleyway subject to truck traffic. Which of the following statements about the grounding electrode conductor is true?

A: The grounding electrode conductor must be protected from physical damage.
B: The grounding electrode conductor cannot be longer than 8 ft.
C: The grounding electrode conductor must be encased in concrete.
D: The grounding electrode conductor must be connected to the grounding electrode by exothermic welding.

Question 76: 250.28(D)(2) Main Bonding Jumper for Service with More Than One Enclosure.

Question ID#: 10418.0

When a service has more than a single service disconnect enclosure, each disconnect enclosure must have its own main bonding jumper. The size of the main bonding jumper in each enclosure is based on the size of the service entrance conductors feeding that enclosure and selected from Table 250.102(C)(1).

For example, a 400 amp service is supplied with 500 kcmil conductors. There are two, 200 amp disconnects, each one supplied with 3/0 cu. conductors. The size of the main bonding jumper in each disconnect is based on the 3/0 cu. wire that supplies that disconnect, not the 500 kcmil conductors.

If the 500 kcmil service conductors fed a metal wireway or common enclosure, the bonding jumper in the metal wireway is based on the 500 kcmil service conductors. The bonding jumper is called the supply-side bonding jumper on the supply side of the service and is sized from Table 250.102(C)(1).

The size of the main bonding jumper is based on the size of the largest phase conductor supplying each enclosure.

Question 76: If a 200 amp service that is supplied with 3/0 copper service entrance conductors has two, 100 amp service disconnects and each is supplied with No. 3 copper conductors, what is the minimum size of the main bonding jumpers in each 100 amp disconnect?

A: No. 8 cu.
B: No. 4 cu.
C: No. 2 cu.
D: No. 6 cu.

Question 77: 250.20(B) Alternating-Current Systems to Be Grounded.

Question ID#: 10405.0

AC systems of between 50 volts and 1000 volts must be grounded.

Alternating-current systems between 50 volts and 1000 volts that supply premises must be grounded under three conditions.

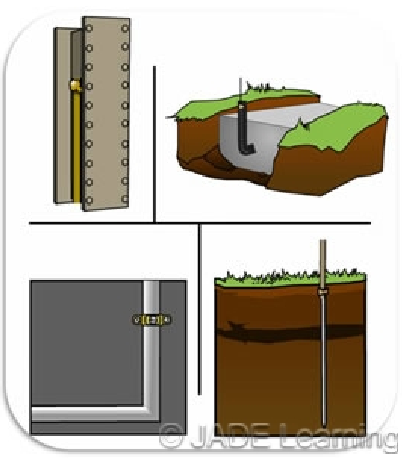
- If the maximum voltage to ground on the ungrounded conductors is not greater than 150 volts. Example: a 120/240 volt service to a single family dwelling.
- If the system is 3-phase, 4-wire, wye connected where the neutral conductor is used as a circuit conductor. Example: a 120/208, 3-phase, 4-wire system created by a transformer.
- If the system is 3-phase, 4-wire, delta connected in which the midpoint of one phase winding is where the grounded neutral conductor is connected. Example: a 120/240 volt system with a high-leg.

Question 77: Which of the following installations is NOT required to be grounded?

A: A 120/240 volt high-leg system.
B: A multi-wire branch circuit used on a 120/240 volt system.
C: A circuit less than 50 volts supplied by a 125 volt grounded transformer.
D: A 120/208 volt 3-phase, 4-wire, wye-connected system.

Question 78: 250.50 Grounding Electrode System.

Question ID#: 10419.0



All grounding electrodes must be bonded together.

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

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

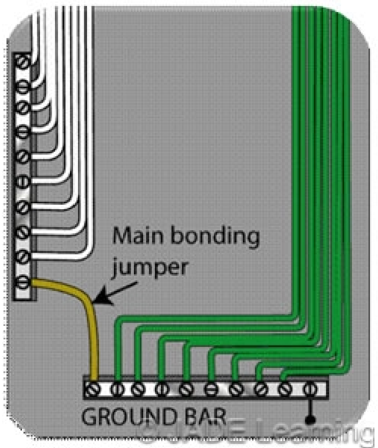
Some state electrical boards have modified this section to say grounding electrodes are required to be bonded to other grounding electrodes if they are ***available,*** not if they are ***present***. For these jurisdictions, if a concrete-encased electrode is buried in the concrete and not available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

Question 78: A grounding electrode system at a building is created by:

A: Driving a ground rod.
B: Bonding service equipment enclosures together.
C: Replacing a short piece of plastic water pipe with metal water pipe.
D: Bonding all grounding electrodes together.

Question 79: 250.24(A)(4) Grounding Service-Supplied Alternating-Current Systems. Main Bonding Jumper as Wire or Busbar.

Question ID#: 10409.0



The grounding electrode conductor can be connected to the equipment grounding bar if the main bonding jumper is a wire or busbar.

The grounding electrode conductor normally connects to the grounded conductor terminal in the meter base or service equipment. The grounding electrode conductor is allowed to connect to the equipment grounding terminal bar in the service equipment only if the grounded conductor terminal and the equipment grounding terminal are tied together with a main bonding jumper that is a wire or busbar.

If there are separate terminal strips for the grounded conductors and equipment grounding conductors, and the main bonding jumper is a screw, the grounding electrode conductor must be connected to the grounded (neutral) terminal bar and not the equipment grounding terminal bar. If the grounded (neutral) conductors and equipment grounds land on the same terminal bar, then the screw used for the main bonding jumper connects to that single terminal bar.

If the main bonding jumper is a wire or busbar, it provides a reliable connection between the grounded conductor terminal and the equipment grounding terminal in the service equipment. The grounding electrode conductor can be installed on the equipment grounding terminal bar as long as the main bonding jumper extends the connection to the grounded terminal bar.

Question 79: Which of the following statements about connecting the grounding electrode conductor at the service is true?

A: The grounding electrode conductor should be insulated from the grounded conductor terminal in the service equipment.
B: The grounding electrode conductor can be connected to the equipment grounding terminal if the main bonding jumper is a screw.
C: The grounding electrode conductor can be connected to the equipment grounding terminal if the main bonding jumper is a wire.
D: The grounding electrode conductor can never be connected to the equipment grounding terminal.

Question 80: 250.24(A)(2) Grounding Service-Supplied Alternating-Current Systems. Outdoor Transformer.

Question ID#: 10408.0

Except for high-impedance grounded neutral systems, a connection between the grounding electrode conductor and the grounded conductor is required at each outdoor transformer, or at some other location outside the building.

Most outdoor transformers are usually installed, owned and maintained by the serving utility and therefore not covered by the NEC.

There are situations where the utility supplies a power distribution center and from that point the power is distributed by the owner to the other buildings on the property. Normally a customer owned transformer is installed at each building on the property. Since the transformers are owned and maintained by the customer, the requirements of the NEC apply, and a connection between the grounding electrode conductor and the grounded conductor is required at the transformer or elsewhere outside the building.

If the transformer is located outside the building, a connection to a grounding electrode is required outside the building.

Question 80: A service supplied by an outdoor transformer:

A: Must have a connection to a grounding electrode conductor outside the building.
B: Does not need a grounding electrode.
C: Must have a connection to a grounding electrode conductor inside the building.
D: Must have a connection at any accessible location.

Question 81: 250.52(A)(3) Concrete-Encased Electrode.

Question ID#: 10422.0

There are two types of concrete-encased electrodes: (1) steel reinforcing bars or rods which are not less than 1/2 inch in diameter and at least 20 ft. long, encased in 2 inches of concrete; (2) 20 ft. of bare copper conductor not smaller than No. 4 AWG encased in 2 inches of concrete.

Concrete-encased electrodes can be horizontal or vertical and must be at least 20 ft. long.

The steel reinforcing rods must be in a location that is in direct contact with the earth. The reinforcing rods can be connected with tie wires, and a single length of rod can be used as the concrete-encased electrode. The reinforcing rods cannot be coated with non-conductive material.

Section 250.50 requires a concrete-encased electrode to be connected to the grounding electrode system if it is present. Several states have modified this requirement to say a concrete-encased electrode must be used as a grounding electrode only if it is available. In those jurisdictions, if the footings or foundations have been poured before the electrical contractor arrives at the site, and a reinforcing rod is not available for use as a grounding electrode, then a grounding connection to the reinforcing rod is not required.

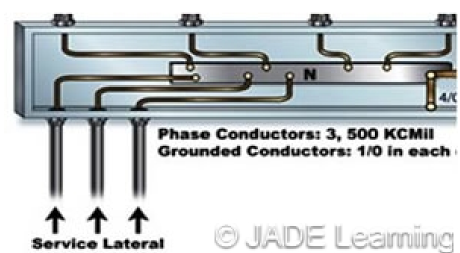
Question 81: Which of the following is considered a concrete-encased electrode?

A: 25 ft. of 1/4 inch steel rebar encased in 2 inches of concrete located at the bottom of the foundation in contact with the earth.
B: 20 ft. of 3/4 inch PVC coated steel rebar encased in 2 inches of concrete located at the bottom of the foundation in contact with the earth.
C: 20 ft. of 3/4 inch steel rebar encased in 2 inches of concrete located within that portion of a concrete foundation or footing that is in direct contact with the earth.
D: 15 ft. of 1/2 inch steel rebar encased in 2 inches of concrete located at the bottom of the foundation in contact with the earth.

Question 82: 250.24(C)(2) Parallel Conductors.

Question ID#: 10414.0

When parallel service conductors are installed in more than a single raceway, the grounded neutral conductor will also be paralleled. The minimum size of the grounded conductor is determined by using NEC Table 250.102(C)(1), based on the size of the individual service conductors installed in that conduit. The grounded conductor however, can never be smaller than 1/0 AWG because the smallest service conductor that can be installed in parallel is 1/0 AWG according to 310.10(H)(1).



When installed in parallel, the size of the grounded conductor is based on the size of the largest phase conductor in each raceway.

In all cases the grounded conductor must be large enough to carry the unbalanced load according to 220.61. Sometimes, the calculation used in 220.61 can result in a larger grounded conductor than what is mentioned in Table 250.102(C)(1).

For example: If three 500 kcmil conductors per phase were installed in 3 separate raceways with one ungrounded 500 kcmil conductor per phase in each raceway, the grounded neutral conductor in each conduit is based on the size of a single 500 kcmil ungrounded conductor in each conduit. From Table 250.102(C)(1), a 1/0 AWG grounded conductor is required.

Question 82: What is the minimum size copper grounded neutral conductor that must be installed in each raceway when 2 raceways are installed with one, 300 kcmil copper conductor per phase in each raceway?

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

Question 83: 250.24(C) Grounded Conductor Brought to Service Equipment.

Question ID#: 10412.0

If the AC system supplying a building is operating at 1000 volts or less and is grounded, the grounded conductor must be run to the building. Even if a neutral conductor is not needed to supply loads in the building, the grounded service conductor must still be installed from the utility source to the building service disconnecting means.

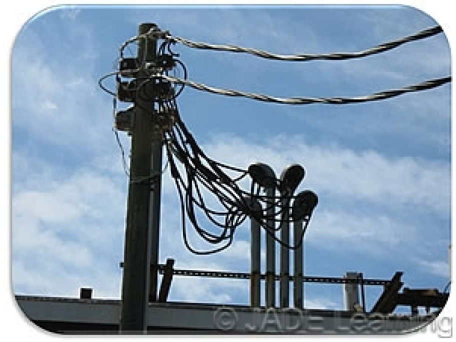
The reason for this is that the grounded service conductor always serves two functions:

1. It carries unbalanced current.
2. It returns ground-fault current to the utility transformer in the event of a ground fault.

Even if the service does not need a grounded neutral conductor for the loads it supplies, a grounded conductor is required to be installed to carry ground-fault current under fault conditions.

If the grounded conductor from a grounded utility transformer is not installed to the building service equipment, the ground-fault current returning to the utility transformer would have to travel through the earth to get back to the utility transformer. The earth should never be used as a ground-fault current path because compared to a copper or aluminum wire it is a very high resistance path.

The high resistance of the earth reduces fault-current to levels that will not trip the breaker protecting the faulted circuit. Then the ground-fault does not clear and equipment enclosures and conduit remain energized.



For grounded AC systems operating at 1000 volts or less, the grounded conductor must be run to each service disconnecting means.

Question 83: Which of the following statements about the grounded service entrance conductor for AC services operating at 1000 volts or less is true?

A: The grounded conductor of a service drop carries only unbalanced current.
B: The grounded conductor of a service drop is not required to be installed unless the loads served require a neutral conductor.
C: The grounded conductor of a service drop carries only ground-fault current.
D: The grounded conductor of a service drop carries both the unbalanced current and serves as a path for ground-fault current.

Question 84: 250.68(C) Grounding Electrode Connections

Question ID#: 10420.0

250.68(C)(1). Metal underground water pipe that is in contact with the earth for at least 10 ft. must be used as a grounding electrode. Copper, iron or steel water pipe is a grounding electrode. Metal water pipe used for drinking water, sprinkler systems or industrial processes are considered grounding electrodes. The size of the water pipe makes no difference. If it is 3/8 inches or 6 inches, metal water pipe must be used as part of the grounding electrode system.

The connection to the metal water pipe must be made within the first 5 ft. of where the metal water pipe enters the building. If there are water meters or sections of insulating joints, a bonding jumper must be installed to make the pipe electrically continuous.

Interior metal pipe is often cut and replaced with plastic pipe. Requiring the connection of the grounding electrode conductor to the metal pipe within 5 ft. of where the pipe enters the building reduces the risk of losing the grounding electrode connection to the grounding electrode.

The connection of the grounding electrode to a continuous metal water pipe must be made when the water pipe first enters the building.

Except in industrial locations, the metal water pipe inside of buildings which is more than 5 ft. from the point of entrance cannot be used to interconnect electrodes. In industrial locations the pipe must be visible for its entire length if it is used to interconnect other electrodes.

250.68(C)(2). The metal structural frame of a building can be used as a way to interconnect grounding electrodes, even if the metal frame of the building is not itself a grounding electrode. For example, if the service is on one side of the building and the water pipe is on the other side of the building, the water pipe can be bonded to the metal frame of the building and the metal frame of the building can be used as a grounding electrode conductor, and be bonded to the service equipment. A separate wire grounding electrode conductor does not have to be run to the distant water pipe.

250.68(C)3). A concrete encased electrode can be extended from its location in the building foundation and turned up to an accessible location, where it can be used to interconnect other grounding electrodes.

Question 84:   When a buried metallic water pipe is used as part of the grounding electrode system, where is the grounding electrode conductor required to be connected to the grounding electrode?

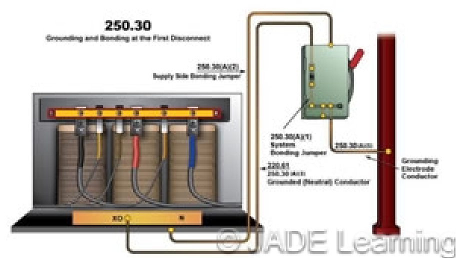
A: To any accessible point on the metallic water pipe regardless of location.
B: On every floor of the building.
C: To an exterior pipe within 5 ft. of where the pipe enters the building.
D: To an interior pipe within 5 ft. of where the pipe enters the building.

Grounding and Bonding at Transformers

Question 85:   250.30(A)(3) Grounded Conductor.

Question ID#: 10441.0

If the grounded neutral conductor is connected to the equipment grounding system at the first disconnecting means, and not at the transformer, the grounded conductor that is installed between the transformer and first disconnecting means will carry fault current back to the transformer if there is a fault on the secondary of the separately derived system. The grounded conductor can never be smaller than the values listed in Table 250.102(C)(1).



If the system bonding jumper is installed at the first disconnect, use Table 250.102(C)(1) to size the grounded conductor between the transformer and first disconnect.

If the grounded conductor is connected to the equipment grounding system at the transformer, then the grounded neutral conductor between the transformer and the first disconnect will not carry fault current. That is the job of the supply-side bonding jumper. The grounded neutral conductor only has to be sized to carry the calculated neutral current, according to Article 220. There is no requirement for the neutral conductor to be sized from Table 250.102(C)(1).

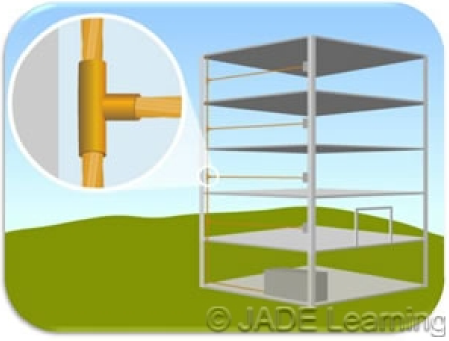
When the grounded neutral carries fault current, it must be routed with the phase conductors and sized from Table 250.102(C)(1) based on the derived phase conductors. If the derived phase conductors are larger than 1100 kcmil cu. or 1750 kcmil aluminum, the grounded neutral conductor must be no smaller than 12.5 % of the area of the phase conductors. If the derived phase conductors are installed in parallel in separate conduits, the grounded neutral conductor is sized based on the largest phase conductor in each conduit, but not smaller than 1/0 AWG.

Question 85: Which of the following installations of the grounded neutral conductor is a code violation?

A: The grounded neutral conductor connected to the equipment grounding system at the transformer and sized to carry the unbalanced neutral current.
B: A No. 1 AWG cu. grounded neutral conductor installed in two parallel conduits where the largest phase conductor in each conduit is 4/0 AWG cu.
C: The grounded neutral conductor connected to the equipment grounding system at the first disconnecting means of the separately derived system.
D: A 1/0 AWG cu. grounded neutral conductor installed in two parallel conduits where the largest phase conductor in each conduit is 2/0 AWG cu.

Question 86: 250.30(A)(6) Grounding Electrode Conductor, Multiple Separately Derived Systems.

Question ID#: 10439.0



Where multiple transformers are installed in a single building, taps from each transformer can be installed to a common grounding electrode conductor.

Taps from multiple separately derived systems are permitted to be connected to a common grounding electrode conductor. These taps are required to connect the grounded conductor of the separately derived system to the common grounding electrode conductor.

The requirements for a common grounding electrode conductor and tap conductors are summarized as follows:

- The common grounding electrode conductor shall not be smaller than a 3/0 AWG CU or 250 kcmil AL.
- The tap conductors from each transformer to the common grounding electrode conductor shall be sized according to Table 250.66 based on the size of the derived phase conductor of the separately derived system.
- All tap connections to the common grounding electrode conductor shall be made in an accessible location by one of the following methods: (1) a listed connector. (2) a listed CU or AL busbar that measures at least 1/4 inch x 2 inches. (3) an exothermic welding process.

In multi-story buildings a common, unspliced, grounding electrode conductor, 3/0 or larger copper, can be run through the building services core. Tap conductors from transformers on each floor can be tapped to the common grounding electrode conductor. This will provide a common grounding point for all electrical systems in the building.

The building steel installed according to 250.52(A)(2) may be used as a grounding electrode, but a single copper grounding electrode conductor with taps to each separately derived system will provide a better path to ground for building electrical systems.

Question 86: The minimum size for a copper common grounding electrode conductor that serves multiple separately derived systems is:

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

Question 87:   250.28(D)(3) Separately Derived System with More Than One Enclosure.

Question ID#: 10434.0

The system bonding jumper is selected from Table 250.102(C)(1) based on the size of the largest ungrounded conductor serving each enclosure.

The system bonding jumper for a separately derived system performs the same function as the main bonding jumper does for a service. Like the main bonding jumper, the size of the system bonding jumper is selected from Table 250.102(C)(1).

If the transformer supplies more than a single enclosure, and the system bonding jumpers are installed in each enclosure, then the size of the system bonding jumper is based on the largest ungrounded conductor serving that individual enclosure.

If a single system bonding jumper is located at the transformer, the size of the system bonding jumper is selected from Table 250.102(C)(1), based on the size of the derived phase conductors. If there are multple sets of derived conductors in parallel, the total sum of the derived conductors is used along with Table 250.102(C)(1).

Question 87:   A transformer supplies three, 200 amp panelboards with 3/0 cu. THHN ungrounded conductors to each panelboard. A system bonding jumper is connected in each enclosure. What is the minimum size system bonding jumper?

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

Question 88:   250.30(A)(8) Bonding.

Question ID#: 10440.0

Building steel and metal water piping in the area serviced by the transformer shall be bonded to the grounded conductor.

The metal frame of the building and the metal water piping that are located in the area served by the separately derived system must be bonded to the grounded conductor of the separately derived system.

The purpose of bonding the building steel and metal water lines to the grounded conductor of the separately derived system is not to connect the separately derived system to a grounding electrode. The purpose is to provide a path for fault current from conductive material like plumbing fixtures or the building steel back to the neutral of the separately derived system.

The water pipe in an area supplied by a transformer could be "high and dry." In other words not being used as a grounding electrode. Water piping cannot be used as a grounding electrode unless it is in direct contact with the earth for 10 feet or more.

The water line could become energized if there was a ground fault on a circuit supplied by the transformer, and if the piping is bonded to the transformer grounded neutral conductor, the fault current has a path back to the overcurrent devices on the separately derived system. If the metal water piping and building steel are bonded correctly, the overcurrent device will trip and de-energize the faulted circuit.

Question 88:   A transformer is located on the third floor of a multi-story building. The interior metal water piping on the third floor:

A: Must be bonded to the transformer grounded conductor.
B: Must be bonded to the water piping on all other floors.
C: Is not required to be bonded to the transformer grounded conductor.
D: Must be used as a grounding electrode.

Question 89: 250.30(A)(5) Grounding Electrode Conductor, Single Separately Derived System.

Question ID#: 10438.0

Separately derived systems require a connection to a grounding electrode.

Separately derived systems must be connected to a grounding electrode. The grounding electrode conductor is connected from the grounded neutral conductor to the grounding electrode.

The grounding electrode conductor is selected from Table 250.66, based on the size of the largest derived phase conductor, or the equivalent area for paralleled conductors. For example, if the largest phase conductor from the secondary of a transformer is a parallel set of two, 500 kcmil cu. conductors, the equivalent area is 1000 kcmil. From Table 250.66, the required grounding electrode conductor for a 1000 kcmil conductor is 2/0 cu.

The grounding electrode conductor must be connected to the grounded neutral conductor at the same location that the system bonding jumper is connected to the grounded neutral conductor. Most often the system bonding jumper is connected at the transformer itself. If so, the grounding electrode conductor must also be connected at the transformer.

Question 89: If the system bonding jumper is connected at the first disconnecting means of the separately derived system, where is the grounding electrode conductor required to be connected?

A: At the transformer or the first disconnecting means.
B: At the first disconnecting means.
C: At the transformer.
D: At the transformer and at the first disconnecting means.

Question 90: 250.30(A)(1) Ex. 2. System Bonding Jumper.

Question ID#: 10437.0

This exception permits a system bonding jumper to be connected at the transformer and at the first disconnect, as long as a parallel path for normal neutral current is not set up. If a system bonding jumper is installed on both ends, the only way to prevent a parallel path for neutral current between the transformer and the first disconnect is to use a nonmetallic wiring method between the transformer and the first disconnect.

If the grounded neutral conductor between the transformer and the first disconnect was installed in metallic conduit, and grounded on both ends, then neutral current would travel on the neutral conductor and on the metallic conduit. This is a parallel path and is not permitted.

Most installers do not use this exception, but as long as a nonmetallic wiring method is installed between the transformer and the first disconnect, a system bonding jumper that connects the grounded neutral conductor to the equipment grounding conductors can be installed at the transformer and at the first disconnect.

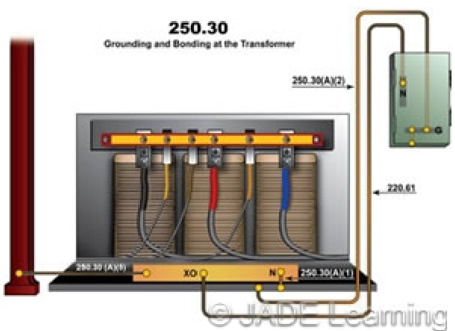
A system bonding jumper can be installed at the transformer and the first disconnect if it does not create a parallel path with the grounded conductor.

Question 90: Which of the following statements about the system bonding jumper is true?

A: Parallel paths for grounded neutral current are not permitted.
B: The system bonding jumper must always be installed at the transformer.
C: The system bonding jumper must be installed at the transformer or at the first disconnect. Never both places.
D: A parallel path for grounded neutral current is permitted if the neutral conductor between the transformer and first disconnect is installed in metallic conduit.

Question 91: 250.30(A)(1) System Bonding Jumper.

Question ID#: 10436.0



The system bonding jumper is usually installed at the transformer and connects the equipment grounding conductors to the grounded conductor.

The system bonding jumper for a transformer is installed without a splice and is used to connect the equipment grounding conductors of the transformer secondary to the grounded secondary conductor. The size of the system bonding jumper is selected from Table 250.102(C)(1) based on the size of the derived phase conductors.

The system bonding jumper can be installed at the transformer or at the first system disconnecting means. Usually the system bonding jumper is installed at the transformer and not at the first disconnecting means.

If there is a ground fault anywhere on the system that is supplied by the secondary of the transformer, the fault current will travel back to the transformer on the supply side bonding jumper.

The system bonding jumper is the bridge between the equipment grounding conductors and the grounded secondary conductor of the transformer. Fault current travels over the system bonding jumper to the grounded conductor at the center point of the transformer windings (for wye connected transformers). This low impedance path keeps the fault current high enough to trip the overcurrent protective device on the faulted circuit.

Question 91: What is the purpose of the system bonding jumper?

A: Connects an ungrounded transformer secondary conductor to the transformer enclosure.
B: Connects the equipment grounding conductors of the secondary to the transformer secondary grounded conductor.
C: Connects the mounting frame of the transformer coils to the transformer enclosure.
D: Connects the primary and secondary grounded conductors together.

Question 92: 250.30 Grounding Separately Derived Alternating-Current Systems.

Question ID#: 10435.0

The system bonding jumper is installed at the source or at the first system disconnecting means.

Separately derived systems are electric power systems created by batteries, generators, solar photovoltaic systems or transformers. Transformers are the most common example of separately derived systems.

From Article 100, a separately derived system has no direct connection from circuit conductors of one system to circuit conductors of another system, other than connections through the earth, metal raceways, or equipment grounding conductors.

Like services, transformers must be grounded at only one location. Once a grounded conductor from the separately derived system is connected to earth and non-current carrying equipment enclosures, it cannot be reconnected to ground at another location.

If the grounded conductor is connected to ground at the transformer enclosure, it cannot be reconnected to ground at the first transformer disconnecting means. If the grounded conductor is connected to earth at the first disconnecting means, then it cannot be grounded at the transformer also. There are exceptions where re-connecting the grounded conductor to ground is permitted.

Question 92: The grounded conductor from the secondary of a transformer is connected to a grounding electrode at the transformer. Without applying any exceptions, which of the following is a true statement about grounding the transformer?

A: The grounded conductor must be isolated from ground in the first disconnecting means enclosure.
B: The grounded conductor can be bonded to the first disconnecting means enclosure.
C: The grounded conductor can be connected to a grounding electrode in the first disconnecting means enclosure.

D: A second system bonding jumper can be installed at the first disconnect.

Grounding and Bonding at Generators

Question 93: 250.35(B) Nonseparately Derived System.

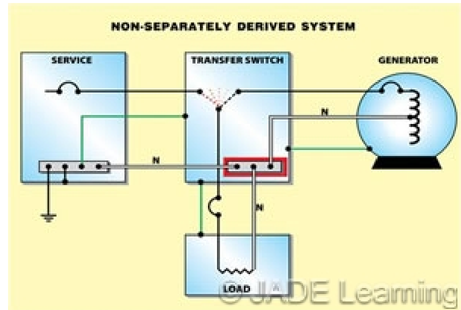
Question ID#: 10447.0

The majority of generators are installed as nonseparately derived systems. This means the generator neutral is isolated from the generator frame, isolated from all other enclosures and has a solid connection to the utility service neutral in the transfer switch.

For generators that create a three-phase, 4-wire system, the transfer switch has 3 poles. For generators that create a single phase, 3-wire system, the transfer switch has 2 poles. The generator neutral is never switched in a nonseparately derived system.

A supply side bonding jumper must be installed between the generator equipment grounding terminal and the equipment grounding terminal or bus of the first disconnecting means.

In a nonseparately derived system, fault current will travel on the equipment grounding conductor back to the service. It will return to the generator on the grounded neutral conductor.



<u>If the generator is installed as a non-separately derived system, a supply side bonding jumper must be installed from the generator to the disconnecting means.</u>

Question 93: Which of the following statements best describes a permanently installed generator connected as a nonseparately derived system?

A: The generator neutral is bonded to the generator enclosure.
B: The generator neutral is not switched in the transfer switch.
C: The generator neutral is bonded to the transfer switch enclosure.
D: The generator neutral is switched when the phase conductors are switched.

Question 94: 250.34(A) Portable and Vehicle-Mounted Generators. Portable Generators.

Question ID#: 10443.0

<u>Portable generators generally do not require a connection to a grounding electrode.</u>

Portable generators are generators that can be easily moved from one place to another. They can be used on construction sites for temporary power, during remodeling and even as optional standby systems. They range in size from 750 watts to 18kw.

A portable generator is not required to be connected to a grounding electrode if the generator supplies only the receptacles on the generator. Normally non-current metal parts of equipment and the equipment grounding terminals of the receptacles must be connected to the generator frame.

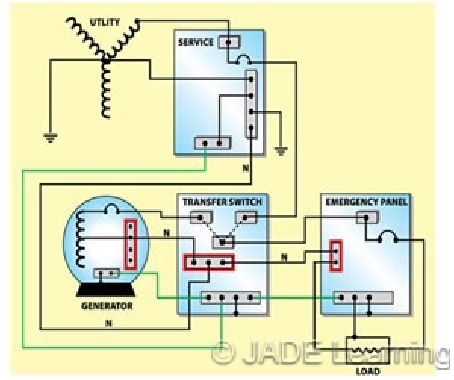
A portable generator usually supplies only equipment which is cord-and-plug connected to the generator through the receptacles mounted on the generator. A portable generator cannot supply a fixed wiring system, such as a circuit breaker panel, without being connected through a transfer switch.

Question 94: Which of the following statements about portable generators is FALSE?

A: They must always be connected to a grounding electrode conductor such as a driven ground rod.
B: They usually supply only the receptacles on the generator.
C: They can be easily moved.
D: The grounding terminal of the receptacles must be connected to the generator frame.

Question 95: 250.35 Permanently Installed Generators.

Question ID#: 10445.0



An effective ground-fault current path is required between a permanently installed generator and the first disconnecting means.

An effective ground-fault current path must be installed between a permanently installed generator and the first disconnecting means. The conductor that is the effective ground-fault current path must be installed with the generator supply conductors.

The purpose of the effective ground-fault current path is to return ground-fault current to the generator so the overcurrent protection in the faulted phase will operate to remove power from the faulted circuit.

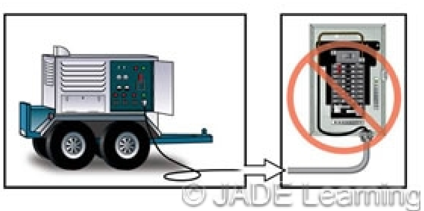
The illustration shows the generator connected as a non-separately derived system. Under normal conditions current flows from the generator to the transfer switch, to the Emergency Panel, to the load. Then it returns on the grounded neutral conductor from the load, to the Emergency Panel, to the transfer switch, back to the generator. If an ungrounded conductor on a load served from the Emergency Panel shorts to ground, fault current will return on the green equipment grounding conductor to the transfer switch, back to the service. At the service the fault current travels over the main bonding jumper to the service neutral. From there it will travel on the neutral conductor back to the generator. The fault current will be high enough to trip the circuit breaker on the faulted phase supplied by the generator.

Question 95: The ground-fault return path for a permanently installed generator must be installed in the following manner.

A: In a conduit by itself.
B: Run with the phase conductors from the generator to the first disconnecting means.
C: Connected to a grounding electrode at the generator.
D: Run exposed from the generator to the transformer.

Question 96: 250.34(B) Portable and Vehicle-Mounted Generators. Vehicle-Mounted Generators.

Question ID#: 10444.0



Vehicle-mounted generators do not require a connection to a grounding electrode if only equipment on the generator is supplied.

Vehicle-mounted generators are mounted on the back of a truck or on a trailer. They are easily moved from one location to another. These generators are used for supplying power when a portable generator does not have enough capacity to feed the load.

When a vehicle-mounted generator only supplies equipment located on the vehicle or cord-and-plug connected equipment through receptacles mounted on the vehicle, the generator is not required to be connected to a grounding electrode.

The grounding terminals on the generator receptacles and other normally non-current carrying metal parts of the equipment on the vehicle must be connected to the generator frame. The frame of the generator is required to be bonded to the frame of the vehicle to eliminate any possibility of a voltage difference between the two frames. Failure to bond the vehicle frame to the frame of the generator could result in a shock hazard under fault conditions.

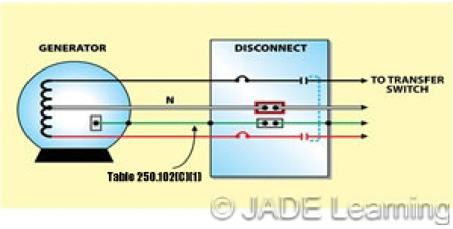
Vehicle-mounted generators cannot supply fixed wiring systems, such as distribution panelboards, unless the generator conductors are connected to the load through a transfer switch.

Question 96: A vehicle-mounted generator supplies cord-and-plug connected equipment through receptacles mounted on the vehicle. Which of the following statements is true?

A: A bonding jumper between the generator frame and the building grounding electrode system must be installed.
B: The generator grounded neutral conductor must be bonded to the premises wiring system.
C: A ground rod is required to be driven and connected to the generator frame.
D: The frame of the generator is required to be bonded to the vehicle frame.

Question 97:   250.35(B) Nonseparately Derived System.

Question ID#: 10448.0



If the generator overcurrent device is located in the disconnecting means, the supply-side bonding jumper is sized from Table 250.102(C)(1).

If a generator is installed as a nonseparately derived system, and the generator does not have overcurrent protection built into the generator, the supply-side bonding jumper between the the generator and the disconnecting means is sized according to 250.102(C).

Section 250.102(C) includes the table for the supply-side bonding jumper, and is based on the size of the largest derived phase conductor.

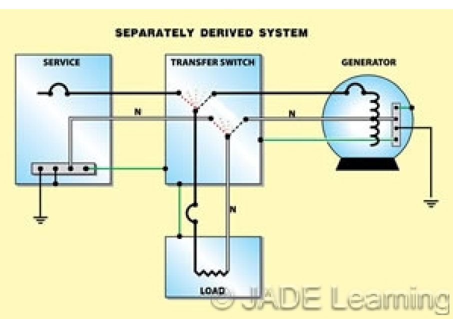
For example, if a generator does not have built in overcurrent protection and the derived phase conductors are 4/0 AWG cu., the supply side bonding jumper cannot be smaller than No. 2 cu., selected from Table 250.102(C)(1).

Question 97:   What size equipment bonding jumper is required for a nonseparately derived system generator where the derived phase conductors are 3/0 copper and the generator overcurrent device is located in the disconnecting means?

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

Question 98:   250.35(A) Separately Derived System.

Question ID#: 10446.0



If a permanently installed generator is installed as a separately derived system, the generator is grounded and bonded just like a transformer.

When a generator is installed as a separately derived system, the grounded neutral is bonded to the frame of the generator. A grounding electrode and grounding electrode conductor are connected to the generator's grounded neutral conductor.

In the transfer switch the grounded neutral from the generator is switched along with the phase conductors. The grounded neutral is isolated from the transfer switch enclosure. A supply-side bonding jumper is installed between the generator and transfer switch to bond the two pieces of equipment together and provide an effective fault-current path back to the generator in case of a ground-fault.

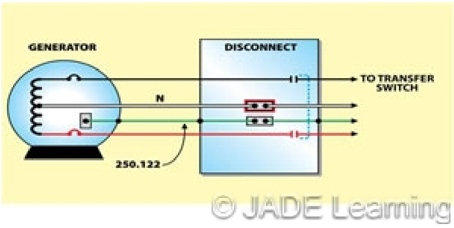
Basically, bonding and grounding a generator that is installed as a separately derived system is just like bonding and grounding a transformer. When there is a ground-fault on a system supplied by a generator installed as a separately derived system, fault current travels on the supply-side bonding jumper back to the generator where the system bonding jumper ties the supply-side bonding jumper to the grounded neutral conductor.

Question 98:   Which of the following statements best describes a permanently installed generator connected as a separately derived system?

A: The frame of the generator serves as the grounding electrode.
B: The grounded neutral from the generator is connected to the grounded neutral of the utility service in the transfer switch.
C: The grounded neutral from the generator is isolated from the generator frame.
D: The grounded neutral is bonded to the generator frame and switched in the transfer switch.

Question 99: 250.32(B)(1) Buildings or Structures Supplied by a Feeder(s) or Branch Circuits(s).

Question ID#: 10449.0



If the overcurrent device is located in the generator, the equipment grounding conductor is selected from Table 250.122.

When a generator is installed as a nonseparately derived system, and the overcurrent protection is located in the generator, the equipment grounding conductor from the generator to the disconnecting means is sized from Table 250.122. Because the derived phase conductors are protected at the generator they are treated as feeder conductors. Equipment grounding conductors installed with feeders are selected from Table 250.122, based on the size of the overcurrent protection ahead of the feeders.

For example, if a generator has overcurrent protection rated at 150 amps, the equipment grounding conductor installed with the derived phase conductors between the generator and the disconnecting means cannot be smaller than No. 6 cu., selected from Table 250.122.

For generators installed as nonseparately derived systems, (1) if the generator has overcurrent protection installed at the generator, then the equipment grounding conductor is selected from Table 250.122. (2) If the generator does not have overcurrent protection at the generator, the supply side bonding jumper is selected from Table 250.102(C)(1).

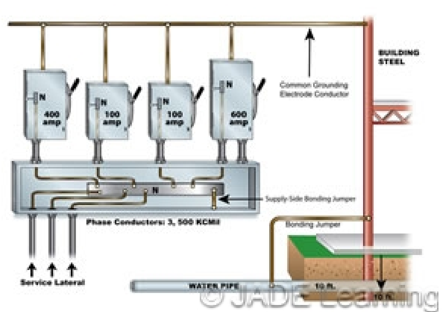
Question 99: What size is the required equipment grounding conductor between the generator and the first disconnect if the nonseparately derived system generator is protected by a 200 amp breaker?

A: No. 4 AWG copper.
B: No. 3 AWG copper.
C: No. 2 AWG copper.
D: No. 6 AWG copper.

Exercises: Grounding and Bonding at the Service.

Question 100: 250.64(D)(1) Service with Multiple Disconnecting Means Enclosures. Grounding Electrode Conductor Taps.

Question ID#: 10455.0



Taps from each service disconnecting means to a common grounding electrode conductor is another way to connect a service to the grounding electrode system.

A third way to connect the grounding electrode conductor to a service that has multiple enclosures is to install grounding electrode conductor taps to a common grounding electrode conductor.

The size of each grounding electrode conductor tap is selected from Table 250.66 based on the largest ungrounded service conductor supplying that service disconnect.

The common grounding electrode conductor that connects each grounding electrode conductor tap to the grounding electrode system is also selected from Table 250.66, but is based on the largest ungrounded service conductor, or the equivalent for paralleled service conductors, supplying the entire service.

Question 100: Three parallel runs of 500 kcmil copper supply a service wireway. Multiple service disconnect enclosures are mounted on the wireway. A grounding electrode tap conductor is installed from each service disconnect to a common grounding electrode conductor. What is the minimum size common grounding electrode conductor required?

A: 3/0 copper.
B: 2/0 copper.
C: 4/0 copper.

D: 1/0 copper.

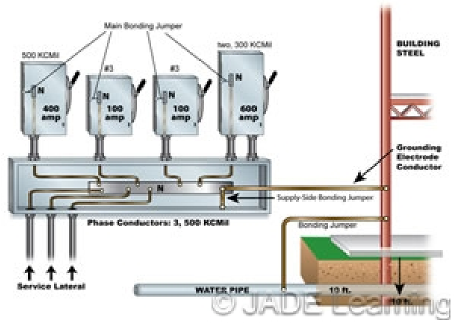
Question 101: 250.64(D)(3) Service with Multiple Disconnecting Means Enclosures. Common Location.

Question ID#: 10451.0

When a service is installed with multiple disconnecting means there are three ways to install grounding electrode conductors. Most often the grounding electrode conductor is installed from a common location, such as a wireway on the supply side of the service disconnecting means.

The grounded (neutral) service conductor is sized according to the largest ungrounded service entrance conductor listed in Table 250.102(C)(1) [250.24(C)(1)].

When conductors are installed in parallel, the grounded (neutral) conductor is run with the phase conductors in each conduit. They are sized according to the largest ungrounded service conductors installed in that conduit [250.24(C)(2)]. Since they are run in parallel, they cannot be smaller than 1/0 AWG. [310.10(H)]



When the service ungrounded conductors are installed in parallel, the grounded neutral conductors must also be installed in parallel.

Question 101: A service is supplied by three parallel 500 kcmil ungrounded copper service conductors in three separate conduits, what is the minimum size grounded (neutral) service conductor in each conduit?

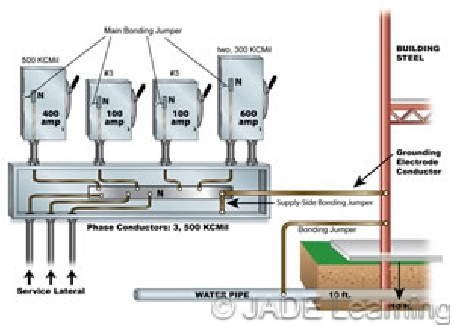
A: 3/0 AWG copper.
B: 2/0 AWG copper.
C: 1/0 AWG copper.
D: 4/0 AWG copper.

Question 102: 250.28(D)(2) Main Bonding Jumper for Service with More Than One Enclosure.

Question ID#: 10453.0

Where a service has multiple enclosures, each service enclosure must have a main bonding jumper to connect the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor within the enclosure for each service disconnect.

This main bonding jumper is sized per Table 250.102(C)(1) for the largest ungrounded service conductor feeding the enclosure.



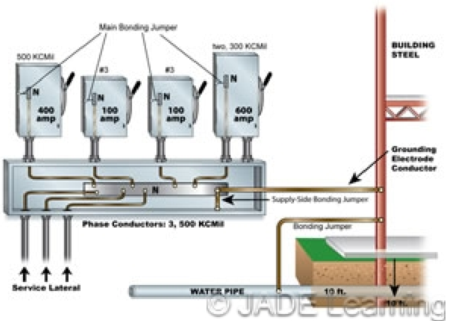
Main bonding jumpers are required in each service disconnecting means.

Question 102: What is the minimum size main bonding jumper for a 400 amp service disconnect supplied by 500 kcmil ungrounded service conductors?

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

Question 103: 250.64(D)(3) Service with Multiple Disconnecting Means Enclosures. Common Location.

Question ID#: 10452.0



The grounding electrode conductor connects the service equipment to the grounding electrode system.

When installing multiple service enclosures for service disconnects, one of the approved methods for installing the grounding electrode conductors is to run from a common location to the grounding electrode. The size of the grounding electrode conductor is selected from Table 250.66, based on the largest ungrounded service conductor supplying the wireway on the supply side of the service disconnecting means.

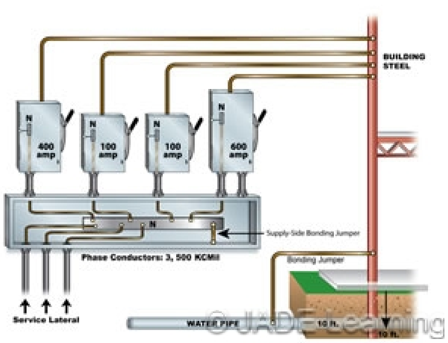
Since the grounding electrode will never see the fault level currents that the main bonding jumper or the equipment bonding jumper on the supply side of the service will see, the grounding electrode conductor never has to be larger than 3/0 copper, no matter how large the service entrance conductors are.

Question 103: A service is supplied by three parallel 500 kcmil ungrounded copper service conductors in three separate conduits, what is the minimum size of the grounding electrode conductor run from the wireway to the building steel?

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

Question 104: 250.64(D)(2) Service with Multiple Disconnecting Means Enclosures. Individual Grounding Electrode Conductors.

Question ID#: 10454.0



Individual grounding electrodes are permitted to connect each service disconnecting means to the grounding electrode system.

A second way to connect the grounding electrode conductor to a service that has multiple enclosures is to install a grounding electrode conductor from each enclosure to the grounding electrode system.

The size of the grounding electrode conductor is based on Table 250.66 for the largest ungrounded service conductor feeding the service enclosure or the equivalent area when installed in parallel.

Question 104: What size grounding electrode conductor is required for a 600 amp service disconnect when supplied with two parallel 300 kcmil ungrounded service conductors?

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

Exercises: Grounding and Bonding Separately Derived Systems.

Question 105: 250.30(A)(1) Grounding Separately Derived Alternating-Current Systems. System Bonding Jumper.

Question ID#: 10457.0

The system bonding jumper is selected from Table 250.102(C)(1). Use the 12.5% rule for phase conductors larger than 1100 kcmil cu. or 1750 kcmil al.

In most field installations, grounding and bonding is done at the transformer. If the system bonding jumper is installed at the transformer, then the grounding electrode conductor must also be connected at the transformer.

When installing the system bonding jumper and the grounding electrode conductor at the transformer, the system bonding jumper and the grounded (neutral) conductors are separated in the first disconnect.

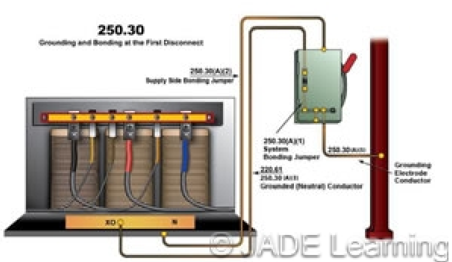
The system bonding jumper is sized per Table 250.102(C)(1) according to the size of the derived phase conductors on the secondary side of the transformer. If the derived phase conductors are larger than 1100 kcmil cu. or 1750 kcmil al., the system bonding jumper shall be sized at not less than 12.5% of the area of the largest phase conductor.

Question 105: What is the minimum size system bonding jumper on the secondary of a 75 KVA transformer where the derived phase conductors are 4/0 AWG cu.?

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

Question 106: 250.30(A)(2) Grounding Separately Derived Alternating-Current Systems. Supply Side Bonding Jumper Size.

Question ID#: 10458.0



If the transformer is grounded at the first disconnect, the supply-side bonding jumper is sized from Table 250.102(C)(1).

When the grounding and bonding of a transformer is done at the first disconnect, instead of at the transformer itself, the supply-side bonding jumper is sized from Table 250.102(C)(1) according to the size of the derived phase conductors on the secondary side of the transformer. The grounding electrode conductor is connected to the grounding electrode system at the first disconnect, rather than at the transformer.

The grounded (neutral) conductor, the system bonding jumper and the supply-side bonding jumper are connected together in the first disconnect. The grounded (neutral) conductor and the equipment bonding jumper are separated at the transformer.

Question 106: What is the minimum size supply-side bonding jumper for a transformer if the derived phase conductors are 500 kcmil copper?

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

Answer Sheet **Darken the correct answer. Sample: A ● C D**

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13.) A B C D	31.) A B C D	49.) A B C D	67.) A B C D	85.) A B C D	102.) A B C D
14.) A B C D	32.) A B C D	50.) A B C D	68.) A B C D	86.) A B C D	103.) A B C D
15.) A B C D	33.) A B C D	51.) A B C D	69.) A B C D	87.) A B C D	104.) A B C D
16.) A B C D	34.) A B C D	52.) A B C D	70.) A B C D	88.) A B C D	105.) A B C D
17.) A B C D	35.) A B C D	53.) A B C D	71.) A B C D	89.) A B C D	106.) A B C D
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