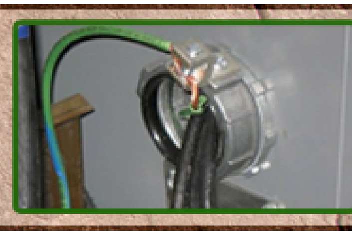
System Grounding & Bonding
(2014 NEC)
JADELearning



System Grounding & Bonding (2014 NEC) (Homestudy)

Oregon Electrical License

This course will cover system grounding and bonding according to the 2014 NEC. The following topics will be covered: grounding and bonding basics, grounding and bonding at services, grounding and bonding at transformers, and grounding and bonding at generators.

Course# 104   4 Code Related Credit Hours $55.00

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

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

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

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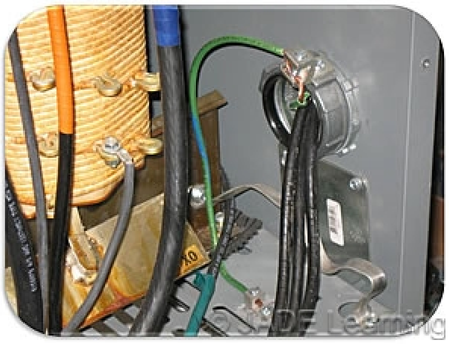
System Grounding & Bonding (2014 NEC) (Homestudy) - OR

Grounding and Bonding Basics

Question 1: 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 1: Which of the following is a performance requirement?

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

Question 2: 250.4(A)(1) Grounded Systems. Electrical System Grounding.

Question ID#: 10400.0

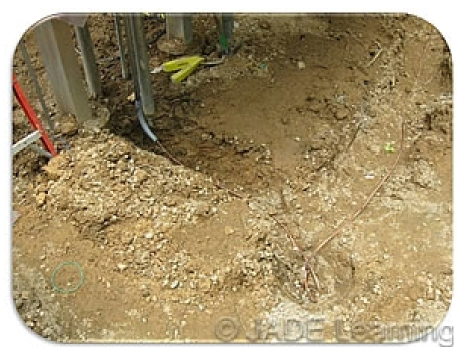
Grounded systems are different from ungrounded systems in two important ways:

- 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.

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."



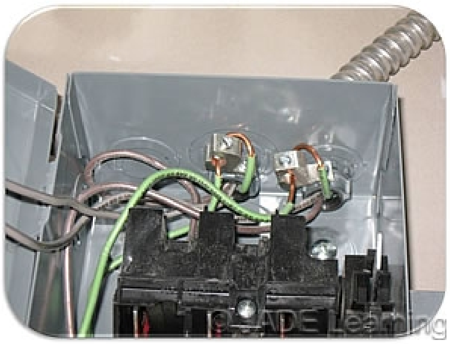
AC systems are grounded to limit the voltage to ground from lightning strikes and to stabilize the voltage to ground during normal operation.

Question 2: In a grounded system:

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

Question 3: 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 3: What does the "grounding" of electrical equipment mean?

A: Adding an additional grounding electrode at the equipment.
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: Installing bonding bushings on conduit.

Question 4: 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 4: What does "bonding" of electrical equipment mean?

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

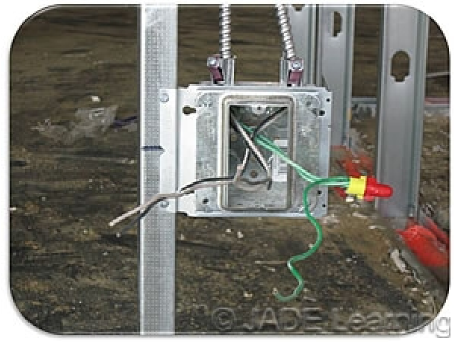
Question 5: 250.4(A)(5) Effective Ground-Fault Path.

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.

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.



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

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

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

Grounding & Bonding At Services

Question 6: 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 6: Which of the following installations is NOT required to be grounded?

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

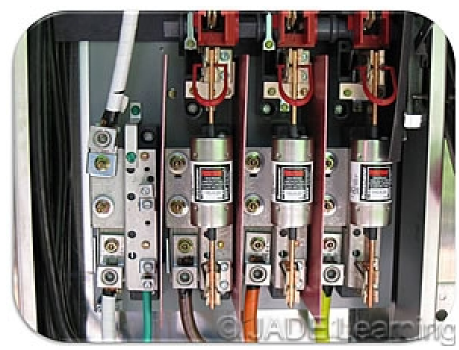
Question 7: 250.24 (A) Grounding Service-Supplied Alternating-Current Systems. System Grounding Connections.

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

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

Question 8: 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 8: 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 a sub-panel.
D: To the grounded conductor terminal in the main service disconnecting means.

Question 9: 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.

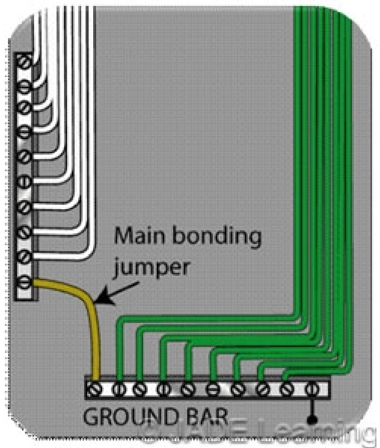
If the transformer is located outside the building, a connection to a grounding electrode is required outside the building.

Question 9: A service supplied by an outdoor transformer:

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

Question 10: 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 10: Which of the following statements about connecting the grounding electrode conductor at the service is true?

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

Question 11: 250.24(A)(5) Grounding Service-Supplied Alternating-Current Systems. Load-Side Grounding Connections.

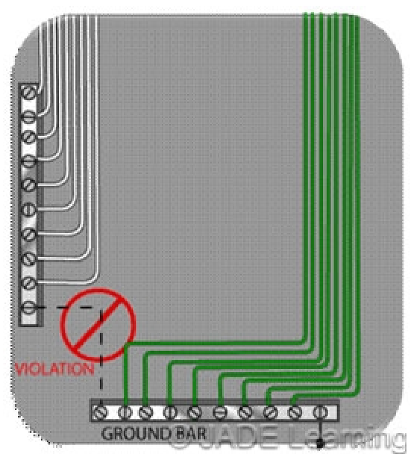
Question ID#: 10410.0

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.***

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.



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

Question 11: Which of the following installations is a code violation?

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

Question 12: 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.

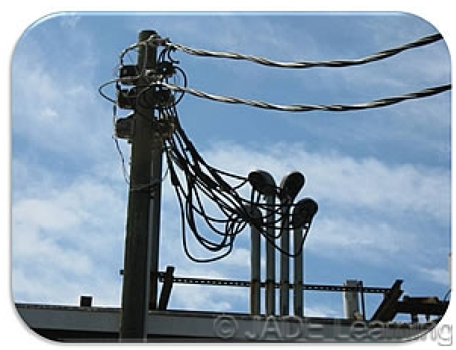
Question 12: Which of the following statements about the main bonding jumper is true?

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

Question 13: 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.



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

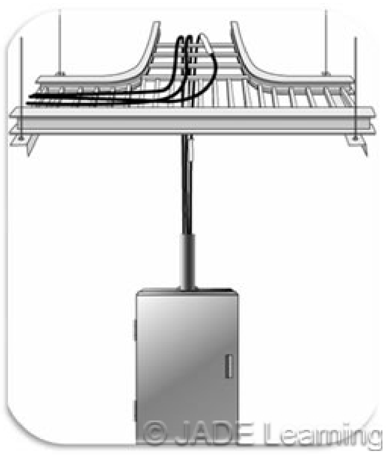
The high resistance of the earth reduces fault-current to levels that will not trip the breaker protecting the faulted circuit. Then the ground-fault does not clear and equipment enclosures and conduit remain energized.

Question 13: 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 14: 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.

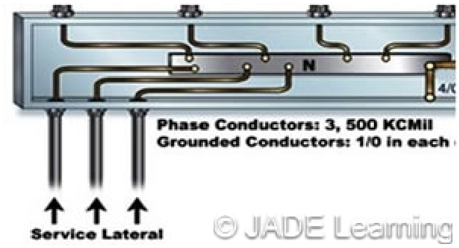
Question 14: What is the minimum size cu. grounded neutral conductor for a service which uses 2/0 cu. ungrounded conductors?

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

Question 15: 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 15: 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: 3/0 AWG.
B: 2/0 AWG.
C: 1/0 AWG.
D: No. 2 AWG.

Question 16: 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.

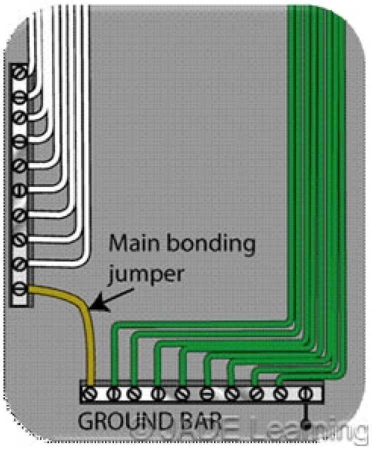
If metal electrical enclosures are at earth potential, then no current can flow from the enclosures through a person's body to ground.

Question 16: A grounding electrode conductor:

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

Question 17: 250.28 Main Bonding Jumper and System Bonding Jumper.

Question ID#: 10416.0



<u>The main bonding jumper is installed at the service. The system bonding jumper is installed at a separately derived system.</u>

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 17: The main bonding jumper connects:

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

Question 18: 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

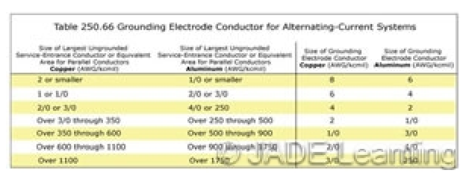


Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

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

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

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.

Question 18:   What size main bonding jumper is required for 500 kcmil cu. service entrance conductors?

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

Question 19:   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).

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

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.

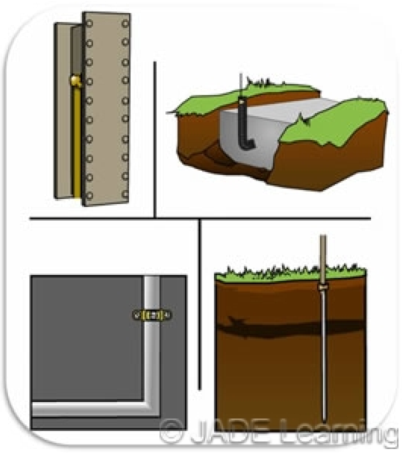
If the 500 kcmil service conductors fed a metal wireway or common enclosure, the bonding jumper in the metal wireway is based on the 500 kcmil service conductors. The bonding jumper is called the supply-side bonding jumper on the supply side of the service and is sized from Table 250.102(C)(1).

Question 19:   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. 6 cu.
C: No. 4 cu.
D: No. 2 cu.

Question 20: 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 20: A grounding electrode system at a building is created by:

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

Question 21: 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 of the grounding electrode to a continuous metal water pipe must be made when the water pipe first enters the building.

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.

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.

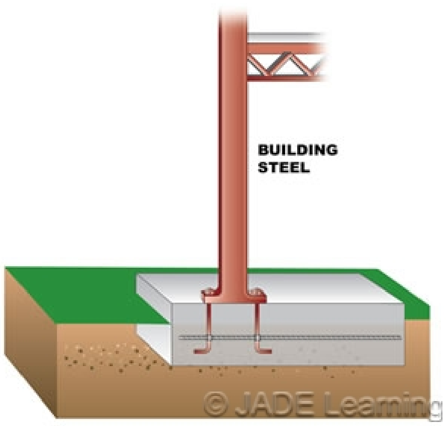
250.68(C)3). A concrete encased electrode can be extended from its location in the building foundation and turned up to an accessible location, where it can be used to interconnect other grounding electrodes.

Question 21: 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: To an interior pipe within 5 ft. of where the pipe enters the building.
C: On every floor of the building.
D: To an exterior pipe within 5 ft. of where the pipe enters the building.

Question 22: 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 22: The metal frame of a building is considered a grounding electrode if:

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

Question 23: 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 23: Which of the following is considered a concrete-encased electrode?

A: 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.
B: 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.
C: 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.
D: 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.

Question 24: 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:

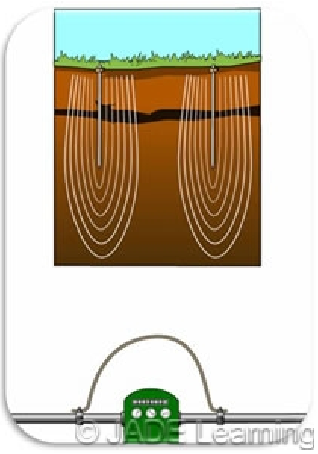
- Underground metal gas pipe systems
- Any underground Aluminum material

Question 24: Which of the following is an acceptable grounding electrode?

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

Question 25: 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.

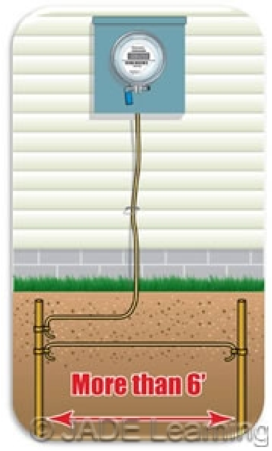
Question 25: Which of the following statements is true?

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

Question 26: 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 26: The measured resistance of a single driven ground rod is 60 ohms. What is required?

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

Question 27: 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 27: 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 connected to the grounding electrode by exothermic welding.
D: The grounding electrode conductor must be encased in concrete.

Question 28: 250.64(D)(1) Service with Multiple Disconnecting Means Enclosures. Grounding Electrode Conductor Taps.

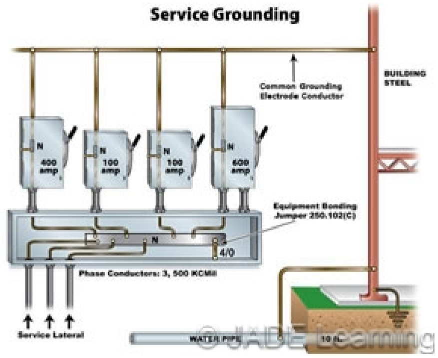
Question ID#: 10427.0

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 28: 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. 6 cu.
B: No. 4 cu.
C: No. 2 cu.
D: No. 1 cu.

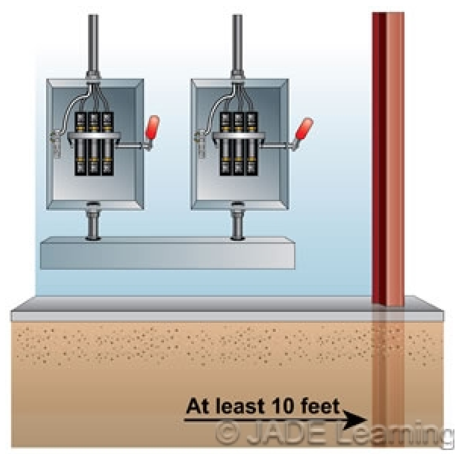
Question 29: 250.64(D)(2) Service with Multiple Disconnecting Means Enclosures.

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 29: 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 - 1/0 cu. / 200 amp disconnects No.6 cu.
D: 400 amp disconnect - 2/0 cu. / 200 amp disconnects No.4 cu.

Question 30: 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 30: 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: 3/0 copper.
B: 4/0 copper.
C: 2/0 copper.
D: 1/0 copper.

Question 31: 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.

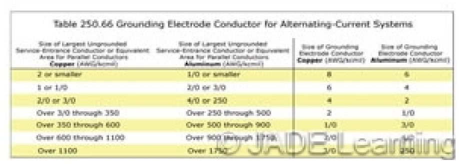


Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

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

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

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

Question 32: 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 32: Which of the following statements about bonding service raceways is correct?

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

Question 33: 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.

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.

An intersystem bonding termination for grounding other systems is required.

Question 33: Which of the following statements about intersystem bonding is correct?

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

Grounding and Bonding at Transformers

Question 34:   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 34:   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: No. 4 cu.
B: No. 2 cu.
C: 1/0 cu.
D: 2/0 cu.

Question 35:   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.

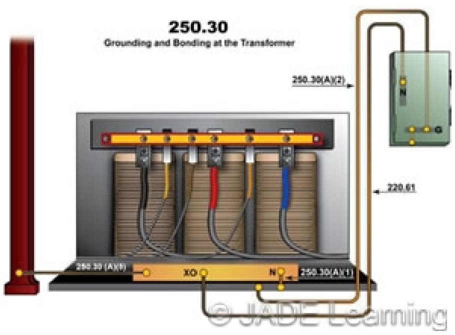
Question 35:   The grounded conductor from the secondary of a transformer is connected to a grounding electrode at the transformer. Without applying any exceptions, which of the following is a true statement about grounding the transformer?

A: A second system bonding jumper can be installed at the first disconnect.
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: The grounded conductor must be isolated from ground in the first disconnecting means enclosure.

Question 36: 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 36: What is the purpose of the system bonding jumper?

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

Question 37: 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 37: Which of the following statements about the system bonding jumper is true?

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

Question 38: 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 38: 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.
B: At the first disconnecting means.
C: At the transformer or the first disconnecting means.
D: At the transformer and at the first disconnecting means.

Question 39: 250.30(A)(6) Grounding Electrode Conductor, Multiple Separately Derived Systems.

Question ID#: 10439.0

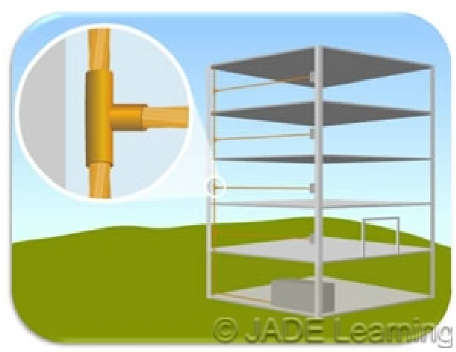
Taps from multiple separately derived systems are permitted to be connected to a common grounding electrode conductor. These taps are required to connect the grounded conductor of the separately derived system to the common grounding electrode conductor.

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.



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

Question 39: The minimum size for a copper common grounding electrode conductor that serves multiple separately derived systems is:

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

Question 40: 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.

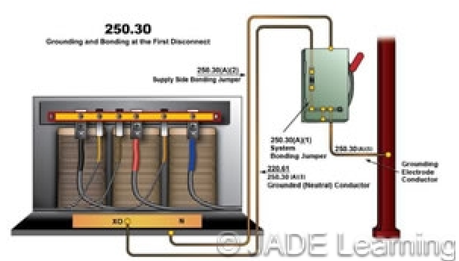
Question 40: A transformer is located on the third floor of a multi-story building. The interior metal water piping on the third floor:

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

Question 41: 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 41: 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 first disconnecting means of the separately derived system.
B: The grounded neutral conductor connected to the equipment grounding system at the transformer and sized to carry the unbalanced neutral current.
C: 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.
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.

Grounding and Bonding at Generators

Question 42: 250.34(A) Portable and Vehicle-Mounted Generators. Portable Generators.

Question ID#: 10443.0

Portable generators generally do not require a connection to a grounding electrode.

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.

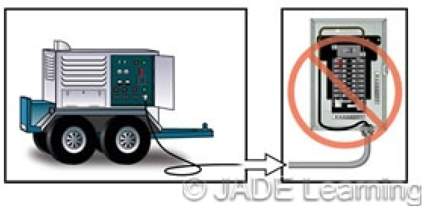
A portable generator usually supplies only equipment which is cord-and-plug connected to the generator through the receptacles mounted on the generator. A portable generator cannot supply a fixed wiring system, such as a circuit breaker panel, without being connected through a transfer switch.

Question 42: Which of the following statements about portable generators is FALSE?

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

Question 43: 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 43: 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: A ground rod is required to be driven and connected to the generator frame.
C: The generator grounded neutral conductor must be bonded to the premises wiring system.
D: The frame of the generator is required to be bonded to the vehicle frame.

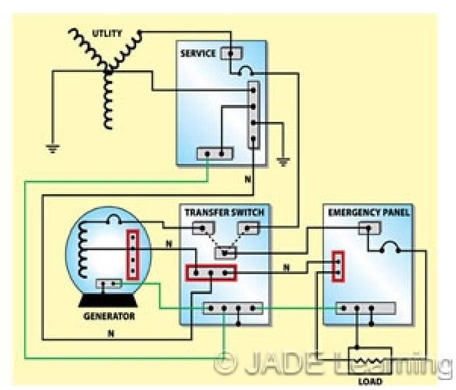
Question 44: 250.35 Permanently Installed Generators.

Question ID#: 10445.0

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.



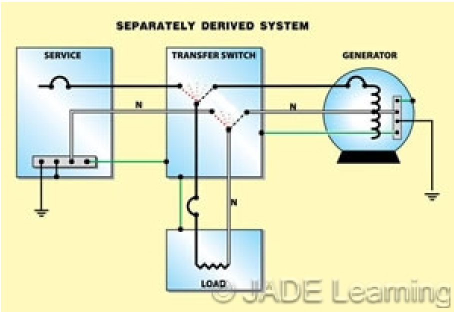
An effective ground-fault current path is required between a permanently installed generator and the first disconnecting means.

Question 44: 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 exposed from the generator to the transformer.
C: Run with the phase conductors from the generator to the first disconnecting means.
D: Connected to a grounding electrode at the generator.

Question 45: 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 45: Which of the following statements best describes a permanently installed generator connected as a separately derived system?

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

Question 46: 250.35(B) Nonseparately Derived System.

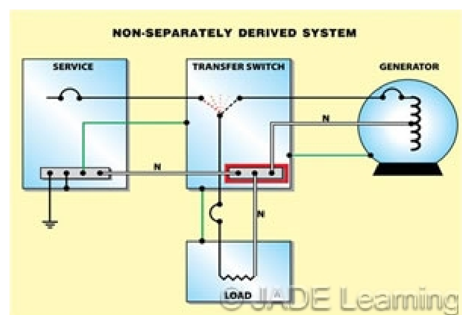
Question ID#: 10447.0

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.



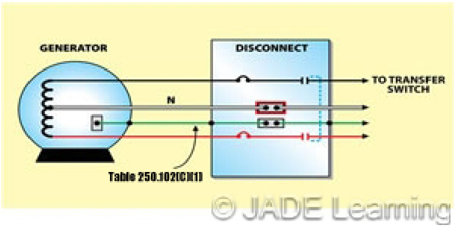
If the generator is installed as a non-separately derived system, a supply side bonding jumper must be installed from the generator to the disconnecting means.

Question 46: Which of the following statements best describes a permanently installed generator connected as a nonseparately derived system?

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

Question 47: 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.

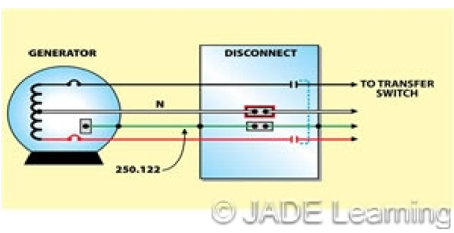
For example, if a generator does not have built in overcurrent protection and the derived phase conductors are 4/0 AWG cu., the supply side bonding jumper cannot be smaller than No. 2 cu., selected from Table 250.102(C)(1).

Question 47: 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: No. 4 AWG copper.
B: No. 2 AWG copper.
C: No. 1 AWG copper.
D: 1/0 AWG copper .

Question 48: 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 48: 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. 6 AWG copper.
B: No. 4 AWG copper.
C: No. 3 AWG copper.
D: No. 2 AWG copper.

Exercises: Grounding and Bonding at the Service.

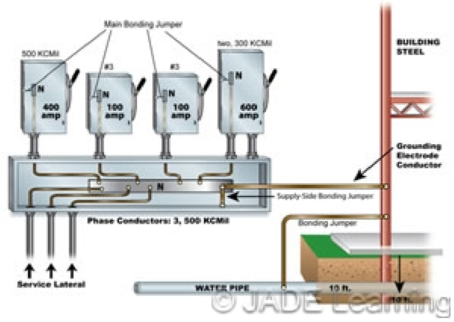
Question 49: 250.64(D)(3) Service with Multiple Disconnecting Means Enclosures. Common Location.

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)]



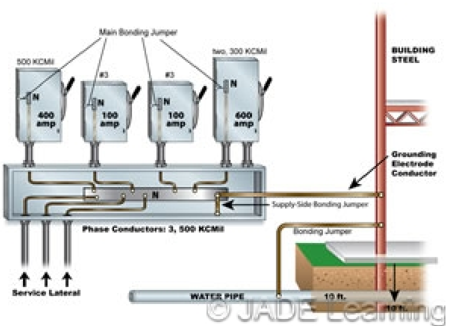
<u>When the service ungrounded conductors are installed in parallel, the grounded neutral conductors must also be installed in parallel.</u>

Question 49: 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: 4/0 AWG copper.
B: 3/0 AWG copper.
C: 2/0 AWG copper.
D: 1/0 AWG copper.

Question 50: 250.64(D)(3) Service with Multiple Disconnecting Means Enclosures. Common Location.

Question ID#: 10452.0



<u>The grounding electrode conductor connects the service equipment to the grounding electrode system.</u>

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 50: 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?

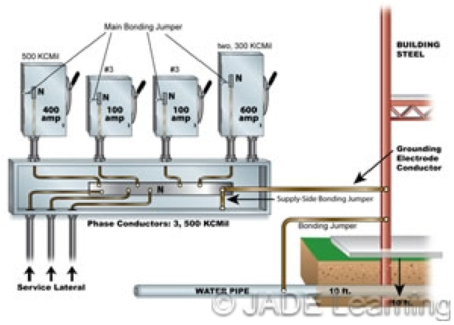
A: 4/0 AWG copper.
B: 3/0 AWG copper.
C: 2/0 AWG copper.
D: 1/0 AWG copper.

Question 51: 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.



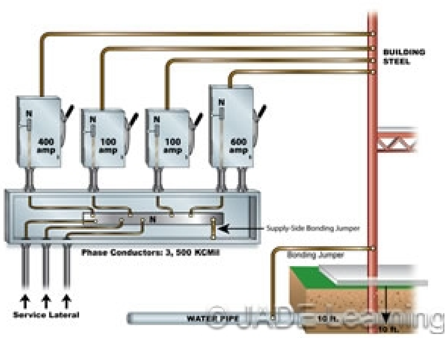
Main bonding jumpers are required in each service disconnecting means.

Question 51: What is the minimum size main bonding jumper for a 400 amp service disconnect supplied by 500 kcmil ungrounded service conductors?

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

Question 52: 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.

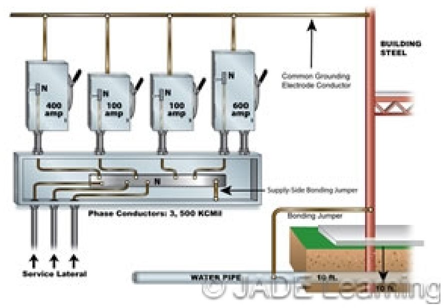
The size of the grounding electrode conductor is based on Table 250.66 for the largest ungrounded service conductor feeding the service enclosure or the equivalent area when installed in parallel.

Question 52: What size grounding electrode conductor is required for a 600 amp service disconnect when supplied with two parallel 300 kcmil ungrounded service conductors?

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

Question 53: 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 53: 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: 1/0 copper.
B: 2/0 copper.
C: 3/0 copper.
D: 4/0 copper.

Exercises: Grounding and Bonding Separately Derived Systems.

Question 54: 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.

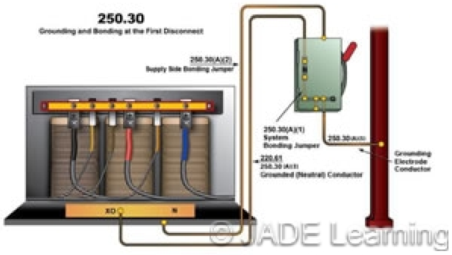
The system bonding jumper is sized per Table 250.102(C)(1) according to the size of the derived phase conductors on the secondary side of the transformer. If the derived phase conductors are larger than 1100 kcmil cu. or 1750 kcmil al., the system bonding jumper shall be sized at not less than 12.5%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

Question 54: 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: No. 1 AWG copper.
C: 1/0 AWG copper.
D: 2/0 AWG copper.

Question 55: 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 55: What is the minimum size supply-side bonding jumper for a transformer if the derived phase conductors are 500 kcmil copper?

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

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

OR System Grounding & Bonding (2014 NEC) Course# 104 4 Code Related Credit Hours $55.00

1.) A B C D
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52.) A B C D
53.) A B C D
54.) A B C D
55.) A B C D

Email answer sheet to: registrar@jadelearning.com

Please fill out the following information and mail this answer sheet along with payment to:
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