Current Flow
1. When electrical current is given multiple conductive paths on which to flow, current will always take the path of least resistance. False. In parallel paths, current divides and flows through each individual parallel path in accordance with Kirchoff’s current law. So, when given multiple conductive paths on which to flow, current will take all of the available paths. Yes, it’s true that more current will flow through the lower resistive path, as compared to a higher resistive path in a parallel circuit, but that’s not the question.

Current Flow
2. It is important to ground metal parts to a suitable grounding electrode, so that in the event of a ground fault, dangerous ground-fault current will be shunted into the earth, away from persons; thereby protecting them against electric shock. False. A person touching an energized metal pole, which is grounded, will experience between 90 and 120 mA of current flow through the body, which is more than sufficient to cause electrocution.

Remember: In parallel circuits, current divides and flows through each individual parallel path in accordance with Kirchoff’s current law.

Current Through Person
I = E/R
I = 90V* / 1,000 ohms**
I = 0.090A or 90 mA

*IIEEE 142, Grounding Industrial and Commercial Installations.

Current Through Ground
I = E/R
I = 120V/25 ohms
I = 4.8A

Because of the earth’s high resistance, it cannot be used as an effective ground-fault current path (250.4(A)(5)); therefore, the grounding conductor for a supplementary electrode is not sized in accordance with the NEC [250.54].

Clear a Fault
4. Electrical equipment must be grounded so that sufficient fault current will flow through the circuit protection device to quickly open and clear the ground fault. For example, a 20A circuit breaker will trip and de-en-

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ergize a 120V ground fault to a metal pole that is grounded to a 25 ohm ground rod.

False. A 120V ground fault that uses the earth as part of the fault return path is not capable of clearing the ground fault [250.4(A)(5)]. Result... dangerous voltage will remain on all metal parts.

If the metal pole were bonded to an effective ground-fault current path, the ground-fault current would be sufficient to quickly open the 20A circuit protection device [250.2 and 250.4(A)(3)]. Result... dangerous voltage on metal parts will be removed.

\[ I = \frac{E}{Z} \]

\[ I = 120V / 0.405 \text{ ohms}^* \]

\[ I = 296A \]

*Effective ground-fault current path:

• Service Feeder: 100 ft of 3/0 AWG Copper
  \[ Z = 0.0766 \text{ ohms per 1,000 ft} \times 0.20 \]  
  (Chapter 9 Table 8)
  \[ Z = 0.015 \text{ ohms} \]

• Branch Circuit: 100 ft of 12 AWG Copper
  \[ Z = 1.93 \text{ ohms per 1,000 ft} \times 0.20 \]  
  (Chapter 9 Table 8)
  \[ Z = 0.39 \text{ ohms} \]

Electrical Equipment

5. Electrical equipment must be grounded to ensure that dangerous voltage on metal parts resulting from a ground fault can be reduced to a safe value.

False. Grounding metal parts to the earth does not reduce voltage on metal parts resulting from a ground fault because the earth cannot serve as an effective ground-fault current path [250.5(A)(5)].

The only way to make this installation safe from a ground fault is to bond the electrical equipment to an effective ground-fault current path so that the fault current will be more than sufficient to quickly open the circuit protection device; thereby clearing the ground fault and removing dangerous touch voltage [250.2 and 250.4(A)(3)].

6. Metal traffic signal poles and handhole covers must be grounded to a suitable grounding electrode to ensure that dangerous voltage on metal parts resulting from a ground fault can be reduced to a safe value.

False. Grounding metal parts to the earth does not remove or reduce voltage on metal parts resulting from a ground fault because the earth cannot serve as an effective ground-fault current path [250.5(A)(5)].

The only way to make this installation safe from a ground fault is to bond service equipment to an effective ground-fault current path so that the fault current will be more than sufficient to quickly open the circuit protection device; thereby clearing the ground fault and removing dangerous touch voltage [250.2, 250.4(A)(3), and 250.24(C)].

Service Equipment

9. Grounding service equipment to a low resistive grounding electrode helps in protecting interior wiring and equipment from lightning damage.

False. Grounding metal parts to the earth does not protect interior wiring or equipment from lightning.

However, grounding service equipment to the earth does reduce the voltage on the metal parts from lightning, which can help prevent a fire caused by elevated lightning voltage seeking a path to the earth by arcing across combustible materials.

Interior wiring and equipment can be protected from lightning-induced voltage transients on the circuit conductors by the use of properly designed cascading TVSS protection devices: one at the service equipment, one at each downstream panelboard, and one at each point of use.

Service Equipment

10. Service equipment is grounded to a grounding electrode to ensure that metal parts, subject to a ground fault, remain at the same potential as the earth.

False. Grounding metal parts to the earth serves no part in reducing the difference of potential between metal parts and the earth from a ground fault.
The only way to make this installation safe is to bond service equipment to an effective ground-fault current path so that the ground fault current will be more than sufficient to quickly open the circuit protection device; thereby clearing the ground fault and removing dangerous touch voltage [250.2, 250.4(A)(3), and 250.24(C)].

Service Equipment
11. Grounding of service equipment to a grounding electrode is necessary to stabilize the system voltage.

False. The earth serves no part in stabilizing the system voltage.

To stabilize the system voltage, a system bonding jumper must be installed at the separately derived system in accordance with 250.30(A)(1).

Service Equipment
12. Service equipment is grounded to a grounding electrode to ensure that the voltage between the metal parts of the electrical installation and the earth remains at the same potential.

False. Grounding service equipment to the earth serves no purpose in establishing or maintaining a zero difference of potential between metal parts of electrical equipment and the earth.

Separately Derived System
13. The metal case of a separately derived system is grounded to a grounding electrode to stabilize the system voltage during normal operation.

False. The earth serves no part in stabilizing the system voltage.

To stabilize the system voltage, a system bonding jumper must be installed between the separately derived system and its metal case in accordance with 250.30(A)(1).

Separately Derived System
14. Separately derived systems are grounded to a grounding electrode to ensure that the voltage between metal parts and the earth remains at the same potential.

False. Grounding a separately derived system to the earth serves no purpose in establishing or maintaining a zero difference of potential between metal parts of electrical equipment and the earth.

Separately Derived Systems
15. Separately derived systems must be grounded to a grounding electrode to ensure that dangerous voltage on metal parts, caused by a ground fault, can be removed or be reduced to a safe value.

The only way to make this installation safe from a ground fault is to bond the metal parts of the separately derived system by using a system bonding jumper so that the ground fault current will be sufficient to quickly open the circuit protection device; thereby clearing the ground fault and removing dangerous touch voltage [250.2, 250.4(A)(3), and 250.4(A)(3)].

Separately Derived Systems
16. An ungrounded system gets its name from the fact that both the separately derived system and the metal case of the separately derived system are isolated from ground (earth).

False. The NEC requires the metal case of ungrounded separately derived systems to be grounded to a grounding electrode [250.30(B)(1)].

Transformers
17. Failure to ground the metal case of a transformer to a grounding electrode can result in a dangerous difference of potential between the metal parts of different separately derived systems.

False: Because all metal parts of electrical installations are required to be bonded to an effective ground-fault current path [250.4(A)(3)], there is no difference of potential between different separately derived systems.

The NEC requires the metal case of all separately derived systems to be grounded to a suitable grounding electrode [250.30(A)(4)], even though there is no technical reason for this.

Generators
18. The metal case of generators are grounded to a suitable grounding electrode to ensure that dangerous voltage on metal parts, caused by a ground fault, can be reduced to a safe value.

False. Grounding parts of the earth does not remove or reduce voltage on metal parts resulting from a ground fault because the earth cannot serve as an effective ground-fault current path [250.5(A)(5)].

The only way to make this installation safe from a ground fault is to bond the metal case of the generator to an effective ground-fault current path so that the fault current will be more than sufficient to quickly open the circuit protection device; thereby clearing the ground fault and removing dangerous touch voltage [250.2, 250.4(A)(3), and 250.30(A)(1)].

Remote Building
19. Building disconnecting means at a remote building supplied by a feeder must be grounded to a grounding electrode to ensure that dangerous voltage on metal parts, caused by a ground fault, can be removed or be reduced to a safe value.

False. Grounding metal parts to the earth does not remove or reduce voltage on metal parts resulting from a ground fault because the earth cannot serve as an effective ground-fault current path [250.5(A)(5)].

The only way to make this installation safe from a ground fault is to bond the building disconnecting means to an effective ground-fault current path so that the fault current will be more than sufficient to

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quickly open the circuit protection device; thereby clearing the ground fault and removing dangerous touch voltage [250.2, 250.4(A)(3), and 250.32(B)].

Remote Building
20. The metal disconnecting means at a remote building, supplied by a feeder with an equipment grounding conductor, is not required to be grounded to a grounding electrode.

False: Grounding of the remote building disconnecting means to the earth is necessary to reduce voltage on the metal parts from lightning; thereby reducing the likelihood of a fire caused by elevated voltage seeking a path to the earth by arcing across combustible materials.

The equipment grounding conductor provides the low-impedance path to the source necessary to clear a ground fault; its function is not to serve as a path for lightning to the earth.

Remote Building
21. The grounding of a building disconnecting means to a suitable grounding electrode helps in protecting interior wiring and equipment from a lightning strike.

False. Grounding metal parts to the earth does not assist in protecting interior wiring or equipment from lightning.

However, grounding the building disconnecting means to the earth does reduce the likelihood of a fire caused by elevated lightning voltage seeking a path to the earth by arcing across combustible materials.

Interior wiring and equipment can be protected from lightning-induced voltage transients on the circuit conductors by the use of properly designed cascading TVSS protection devices: one at the service equipment, one at each downstream panelboard, and one at each point of use.

Outdoor Metal Pole
22. Outdoor metal light poles must be grounded to a suitable grounding electrode to ensure that dangerous voltage on metal parts, caused by a ground fault, can be reduced to a safe value.

False. Grounding metal parts to the earth does not remove or reduce voltage on metal parts resulting from a ground fault because the earth cannot serve as an effective ground-fault current path [250.5(A)(5)].

The only way to make this installation safe from a ground fault is to bond the metal light pole to an effective ground-fault current path so that the fault current will be more than sufficient to quickly open the circuit protection device; thereby clearing the ground fault and removing dangerous touch voltage [250.2 and 250.4(A)(3)].

Outdoor Metal Pole
23. Grounding metal light poles to a grounding electrode helps in reducing lightning damage to the luminaires on the metal light pole from a direct lightning strike.

False: If lightning strikes the pole, the luminaire on the pole is toast. Nothing can be done about this.

Outdoor Metal Pole
24. Grounding metal light poles to a grounding electrode helps in preventing damage to building wiring and equipment from lightning striking one of the metal light poles.

False: Grounding a metal light pole to the earth does nothing to prevent damage to interior wiring and equipment of a building from lightning.

Interior wiring and equipment can be protected from lightning-induced voltage transients on the circuit conductors by the use of properly designed TVSS protection devices.

Outdoor Metal Pole
25. Grounding metal light poles to a grounding electrode is necessary to prevent lightning damage to the concrete pole base.

False: Ralph Lee, in a 1966 study, proved that lightning does not crack the concrete of a concrete encased grounding electrode.

Sensitive Electronic Equipment
26. Studies have shown that a low-resistive grounding system improves power quality for sensitive electronic equipment.

False: The earth serves no purpose in improving power quality.

Sensitive Electronic Equipment
27. Single-point grounding improves equipment performance by preventing ground-loop currents.

False: Grounding sensitive electrical equipment to the same electrode serves no purpose in preventing or reducing ground-loop currents. This is because ground-loop currents flow when improper neutral-to-ground connections are made on the load side of service equipment or separately derived systems in violation of 250.142. To remove ground-loop currents, simply ensure the installation is in compliance with the NEC.

Sensitive Electronic Equipment
28. Studies have shown that grounding sensitive electronic equipment to an isolated counter-poise ground improves equipment performance because of improved power quality.

False: Grounding sensitive electronic equipment to the earth serves no purpose in improving equipment performance or power quality.

Sensitive Electronic Equipment
29. If an electrical system is properly installed, the voltage between the neutral terminal and the ground terminal at a receptacle should be near zero.

False: The voltage between the neutral and ground terminals at a receptacle will never be near zero.
volts in a building that has power.

For example: the NEC recommends a maximum voltage drop of 3% for the feeder, which works out to be 3.6V for a 120V circuit. Under this condition, the voltage (feeder neutral voltage drop) between the receptacle’s neutral and ground terminals would be 1.8V if no current flows through the branch circuit supplying the receptacle.

A study by the Electrical Power Research Institute (EPRI) demonstrated that elevated neutral-to-ground voltage has no effect on equipment performance.

**Stray Voltage or Neutral-to-Earth Voltage (NEV)**

30. Grounding premises wiring to a low resistive grounding grid can help reduce stray voltage or neutral-to-earth voltage on metal parts.

False: Grounding metal parts to the earth serves no purpose in reducing stray or NEV voltage.

However, bonding metal parts together reduces the difference of potential between the metal parts, but the stray or NEV voltage, as measured between the metal parts and the earth, will not be reduced.

Stray voltage or neutral-to-earth voltage can come from the electric utility’s distribution system, the building’s electric system, or both of these sources.

**Stray Voltage or NEV**

31. Grounding metal parts of electrical equipment to an equipotential plane can help reduce stray or NEV voltage on the metal parts.

False: Bonding metal parts to an equipotential plane does reduce the difference of potential between the metal parts and the equipotential plane, but stray or NEV voltage, as measured between the metal parts and the earth, will not be reduced.

**TVSS**

32. A low resistive earth ground is necessary for the proper operation of transient voltage surge suppressors (TVSSs).

False. The earth serves no purpose in the operation of a TVSS device.

TVSS protection devices protect electrical equipment by shunting high-frequency impulse currents away from the load and back to the source via the circuit conductors, not via the earth.

**General**

33. Because salt water is more conductive than fresh water, a person is more likely to be electrocuted while swimming at a saltwater marina, than a freshwater marina.

False: Because the voltage gradient in salt water much lower than fresh water, the likelihood of death will be greater in a fresh water marina.

Mike Holt is a leading NEC consultant, author and instructor. His web site is the #1 rated electrical web site in the world. His new text on grounding, Grounding Versus Bonding, is an excellent reference for you to understand the above quiz. Find Grounding Versus Bonding and more at [www.mikeholt.com](http://www.mikeholt.com).

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