



## Grounding and Bonding Fundamentals

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Welcome to a NECA Webinar based on the National Electrical Code. This seminar is the first in a short series of electrical grounding and bonding Webinars presented by NECA. Introduction of speaker and subject.

## **Objectives:**

- Review of grounding and bonding terminology
- Review the defined terms related to the subject
- Review of basic grounding concepts (purpose)
- Review of basic bonding concepts (purpose)
- How grounding and bonding concepts work together
- Review system grounding concepts
- Review equipment grounding concepts

The presenter reviews the objectives of the Webinar during this slide. It is important that the student understand that this portion of the Webinar series on Electrical Grounding and Binding Fundamentals covers the basics regarding defined terms. Grounding concepts, bonding concepts, and overcurrent device operations.

## Common Language of Communication

- It is important to use the terms that are used in the *NEC*.
- Slang words or trade jargon have different meanings for different people.
- Use and understanding of defined grounding and bonding terms help in proper application of *NEC* rules.

It is important the industry use a common language of communication when relating to technical and Code requirements. Many in the electrical field use terms they are familiar with, but these terms may not be defined by the NEC. Using the language the Code uses promotes accuracy in application of the requirements. Use of slang terms can result in the wrong rule being applied.

## Article 100 – Definitions

- Grounding and bonding terms have been revised and simplified for clarity and improved usability.
  - Bonded (Bonding) – Revised
  - Ground – Revised
  - Grounded (Grounding) – Revised
  - Grounded, Effectively – Deleted

11/3/2008

This slide provide instructors with an opportunity to discuss various NEC terms related to grounding and bonding that have either been revised or are new in the 2008 NEC cycle. The primary reason for the revisions was to simplify meanings for improved usability and clarity.

## **Articled 100 – Definitions (cont.)**

- Grounding Conductor, Equipment (EGC) – Revised
- Grounding Electrode – Revised
- Grounding Electrode Conductor – Revised
- Ungrounded – New

(Continuation) This slide provide instructors with an opportunity to discuss various NEC terms related to grounding and bonding that have either been revised or are new in the 2008 NEC cycle. The primary reason for the revisions was to simplify meanings for improved usability and clarity.

## The Purpose of Bonding

- The purpose is to establish continuity and conductivity.
- Minimizes potential differences between conductive material or parts.
- Connects conductive parts together and to the electrical supply source in a manner that establishes an effective ground-fault current path.
- *NEC* 250.4(A)(3) and (4)

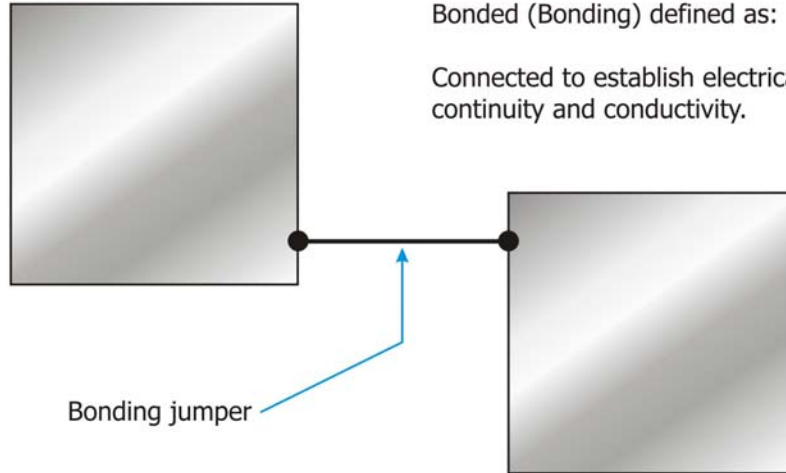
The purpose is evident in the definition of the term and the performance language provided in Section 250.4(A)(3) and (4). Bonding connects electrical conductive parts together to minimize potential differences and forms an effective path for fault current.

## Bonded (Bonding)



Bonded (Bonding) defined as:

Connected to establish electrical continuity and conductivity.



Bonding jumper

This slide is used to graphically support the defined term. Continuity and conductivity are established through effective bonding.

## Bonded (Bonding)

- Bonded (Bonding). Connected to establish electrical continuity and conductivity.
- Bonding is the process of connecting objects together.
- The *NEC* uses the terms in a couple different ways.
- Section 250.90 addresses bonding in a manner to handle fault currents imposed.
- Section 680.26 addresses bonding to establish an equipotential bonding grid (shock protection).

Instructors should use this slide to support the reason for the revision of the definition of the term Bonded (Bonding). The key performance actions accomplished by bonding are establishing continuity and conductivity.



## Ground

- The earth
- Use of the term ground refers to an action related to the planet earth.

The term Ground has been totally redefined in the 2008 NEC. The term is no longer defined using several performance concepts. This term simply refers to the earth. When NEC rules use the term ground, the earth is what is implied, not anything that would serve in place of the earth.

## Ground



The term *ground* is defined in Article 100 as the *earth*.



When conductive objects, conductors, or systems are required to be grounded, a connection to the planet earth is implied.

Ground is defined as the earth. Therefore when the NEC refers to the ground in various rules, a connection to the planet is implied. Grounding electrodes are used to make electrical connections of systems and equipment to ground (or the earth).

## The Purpose of Grounding

- Electrical systems are grounded to limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation.
- Conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, must be connected to earth so as to limit the voltage to ground on these materials.
- *NEC* 250.4(A)(1) and (2)

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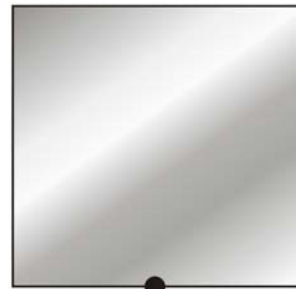
This slide provides the purpose of system and equipment grounding as provided in Section 250.4(A)(1) and (2). Systems are grounded to limit the voltage imposed by lightning, line surges, and unintentional contact with higher-voltage lines. Grounding stabilizes system voltages to ground during normal operation.

## Grounded (Grounding)

- Connected (connecting) to ground or to a conductive body that extends the ground connection.
- Conductive objects that extend the ground connection could be equipment grounding conductors, grounding electrode conductors, grounded conductors, and so forth.

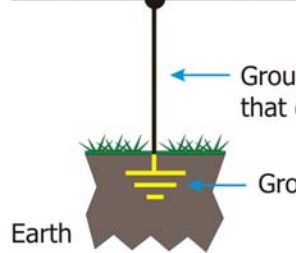
The term grounded (grounding) has been revised to accurately describe the action happening through the process of grounding. Because the definition of the term ground is the earth, when a Code rule requires that a system or equipment be grounded, a connection to the planet earth is required. The revision also replaces the previous language that implied that grounding meant a connection to earth or a conducting body that served in place of the earth. The revision clarifies that earth substitutes are not required here, but connections to conductive bodies that extend the earth connection are what is intended. An example is an equipment grounding conductor.

## Grounded (Grounding)



Grounded (grounding) defined as:

Connected (connecting) to ground or to a conductive body that extends the ground connection.



← Grounding electrode conductor is a conductive body that extends the ground connection.

← Grounding electrode

Earth

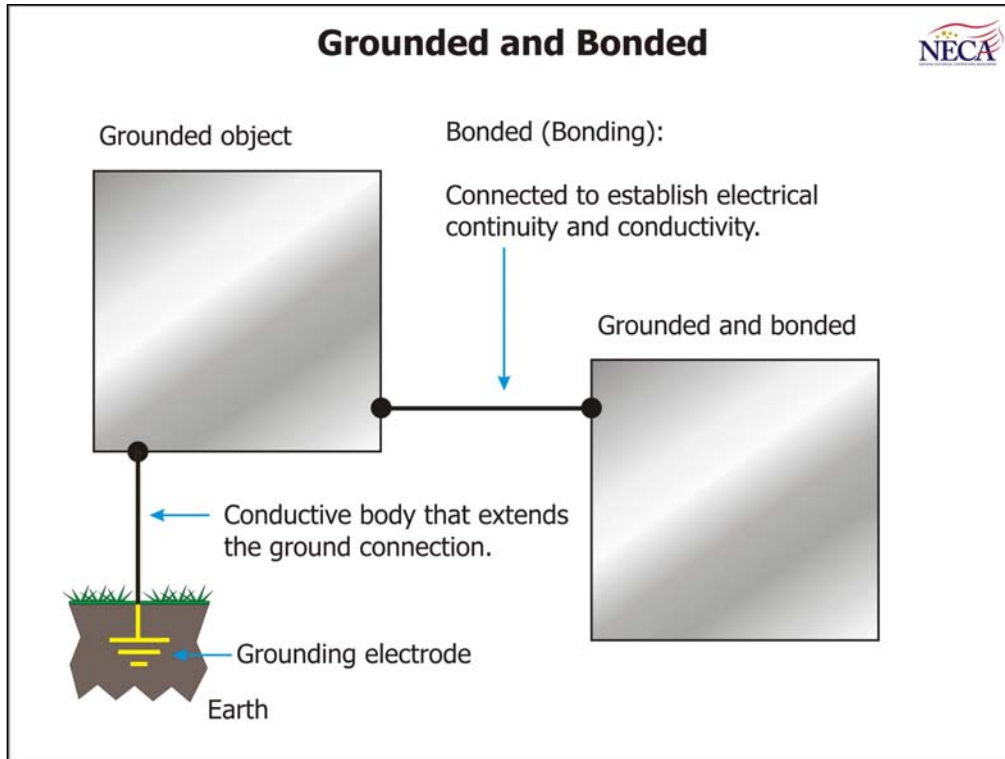
This slide provides instructors with an opportunity for a graphic description of the revised term grounded (grounding). Note that the grounding electrode conductor serves as a conductive body that extends the earth connection.

## Grounding and Bonding

- Grounding is the process of connecting a system, equipment, or both to the earth.
- Bonding is the process of connecting to conductive objects together.
- Grounding and bonding means that conductive parts are connected together and to the earth.

Grounding and bonding are actions that are simultaneous in electrical installations. Electrical systems and equipment are grounded, usually at the source or service. Other conductive parts are bonded together and connected to the earth through a grounding electrode conductor connection either at the service or source of a separately derived system.

## Grounded and Bonded



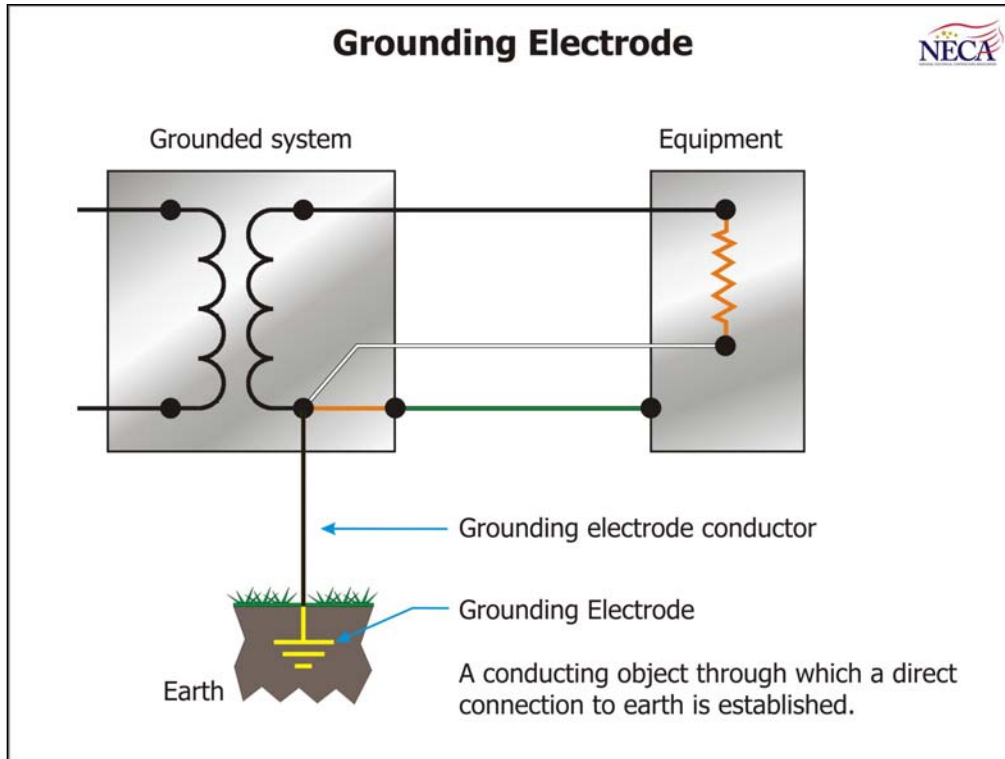
This slide is a basic graphic representation of grounding and bonding concepts performing simultaneously. Note that both grounding and bonding concepts are present. The same holds true for electrical installations.

## Grounding Electrode

- A conducting object through which a direct connection to earth is established.
- The definition of grounding electrode has been revised for the 2008 Code to clarify its function.
- Grounding electrodes recognized in the *NEC* are provided in 250.52(A).

The grounding electrode has an important role in the grounding action. This is the conductive object that makes the connection to the planet. Section 250.52(A) provides Code-recognized grounding electrodes. The definition has been revised in the 2008 NEC to clarify its function.





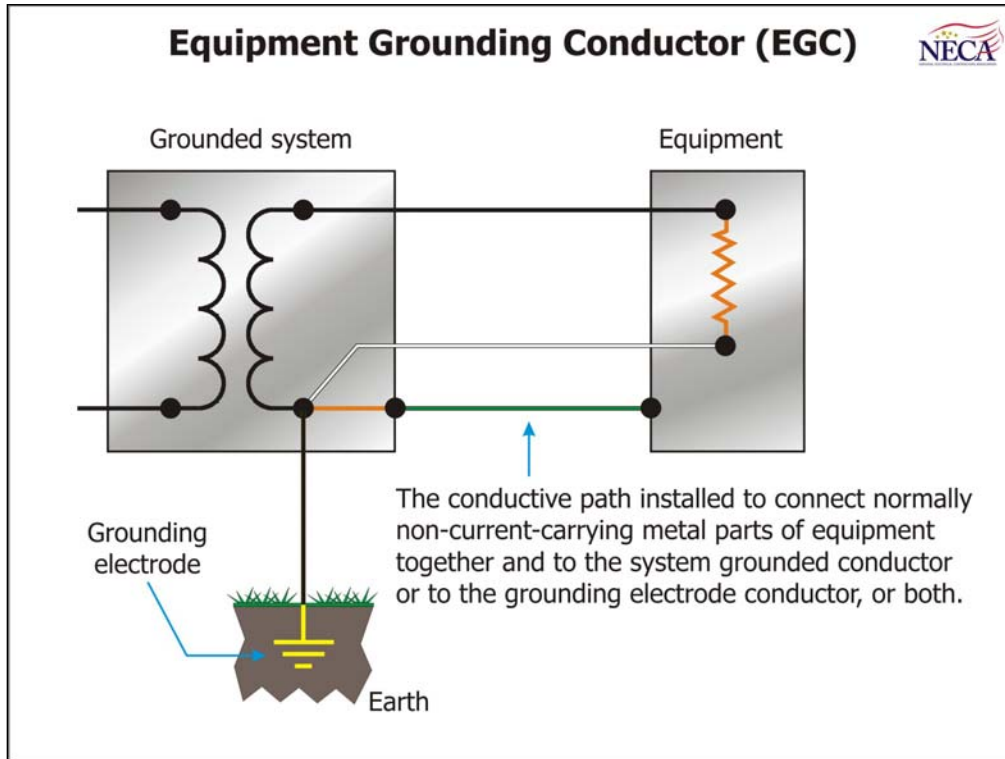
Instructors can use this slide to discuss the grounding electrode and the role of the earth in the electrical circuit. The earth has a role in the electrical grounding circuit, but it is not the role of facilitating overcurrent device operation. The earth is a high-impedance path.

## Grounding Conductor, Equipment (EGC)

- The conductive path installed to connect normally non-current-carrying metal parts of equipment together and to the system grounded conductor or to the grounding electrode conductor, or both.
  - FPN No. 1: It is recognized that the equipment grounding conductor also performs bonding.
  - FPN No. 2: See 250.118 for a list of acceptable equipment grounding conductors.

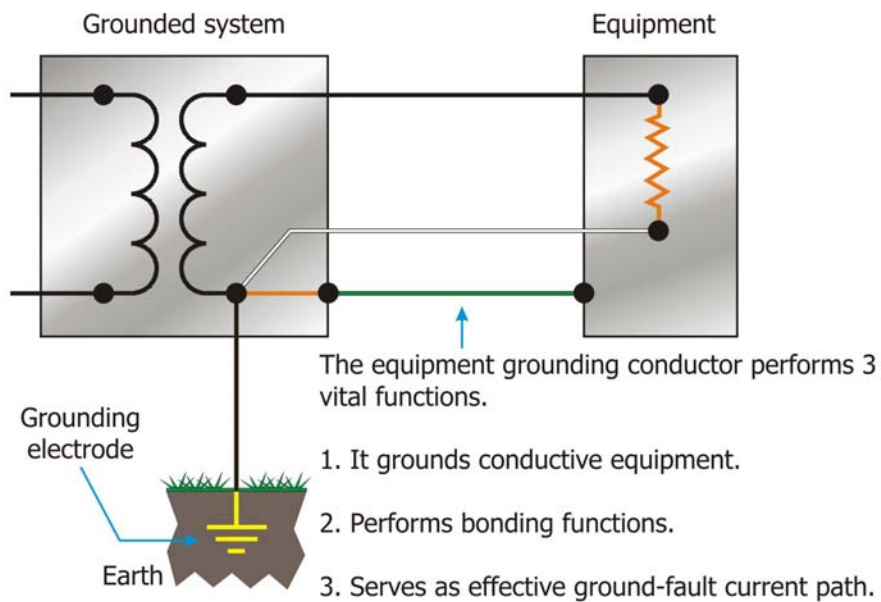
The definition of the term equipment grounding conductor has been revised to accurately reflect this conductor's performance characteristics. The concepts of bonding are incorporated into the definition by the inclusion of the words "connect" and "together". Equipment grounding conductors perform grounding, bonding, and serve as effective ground-fault current paths in ground fault conditions. These conductors are multi-tasking.

## Equipment Grounding Conductor (EGC)



This slide graphically illustrates all grounding and bonding components. The equipment grounding conductor (EGC) is the safety circuit for the equipment connected to electrical circuits.

## Equipment Grounding Conductor (EGC)

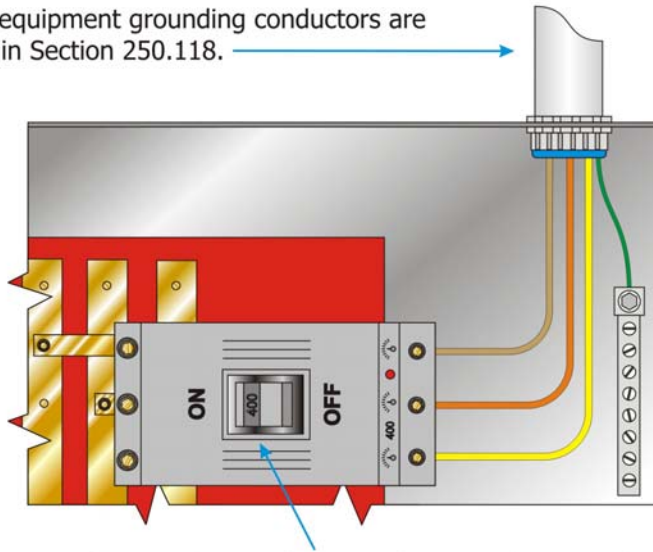


Three vital functions performed by the equipment grounding conductor are grounding of equipment, bonding of conductive parts together, and performing as an effective ground-fault current path during abnormal events such as ground faults.

## Equipment Grounding Conductors



Types of equipment grounding conductors are provided in Section 250.118. →



Equipment grounding conductors (wire-type) are sized in accordance with Section 250.122 and Table 250.122 based on the overcurrent device protecting the circuit.

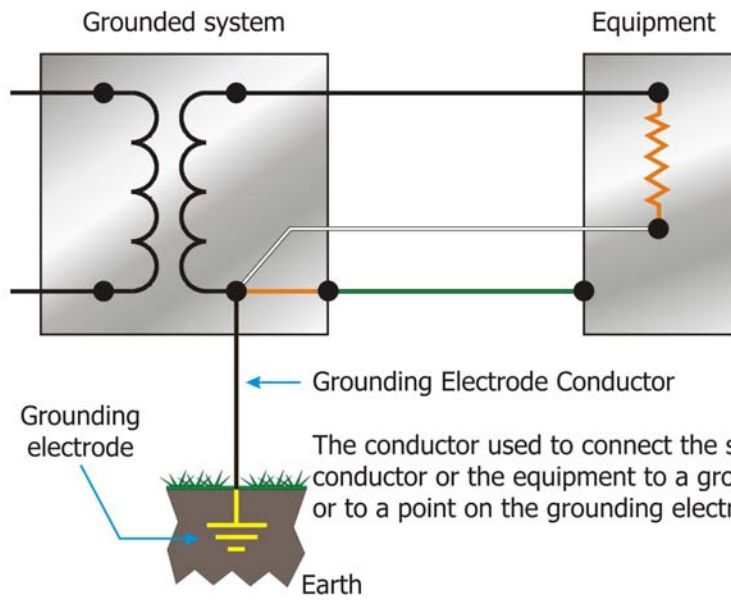
The types of equipment grounding conductors are provided in Section 250.118 of the NEC. Section 250.122 and Table 250.122 provide sizing requirements for equipment grounding conductors. The overcurrent device is key to selection of the minimum size equipment grounding conductor (wire-type).

## Grounding Electrode Conductor

- A conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.
- Grounding electrode conductor installation requirements are provided in Section 250.64.
- Grounding electrode conductors are sized using Section 250.66(A) through (C) and Table 250.66.

The **grounding electrode conductor** is a conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system. Instructors should discuss sizing requirements for grounding electrode conductors provided in Section 250.66 and grounding electrode conductor installation requirements contained in 250.64. Protection requirements in Section 250.64 include protection from physical damage and protection against magnetic fields when the GEC is installed in a ferrous metal enclosure.

## Grounding Electrode Conductor



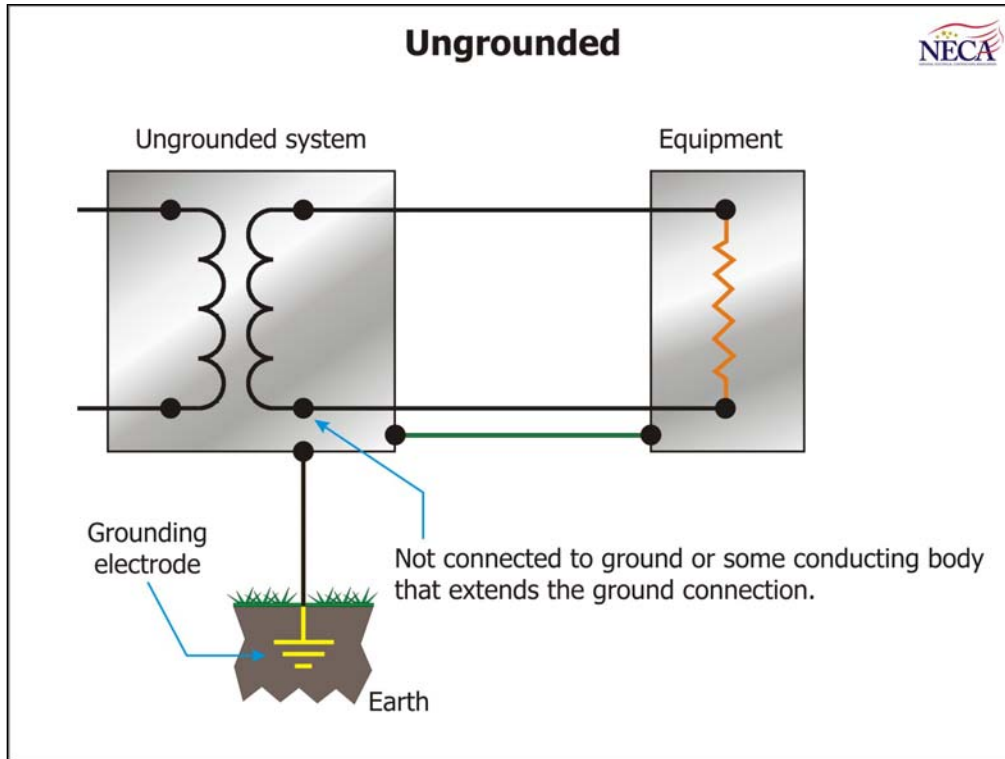
This slide provides a graphic illustration showing the grounding electrode conductor connection to the system and the equipment. Grounding electrode conductors are a conducting body that extends the connection to ground.

## Ungrounded

- Not connected to ground or to a conductive body that extends the ground connection.
- The definition of the term ungrounded grounded is the opposite of the definition of grounded (grounding).

The definition of the term “ungrounded” is the opposite of the term “grounded.”



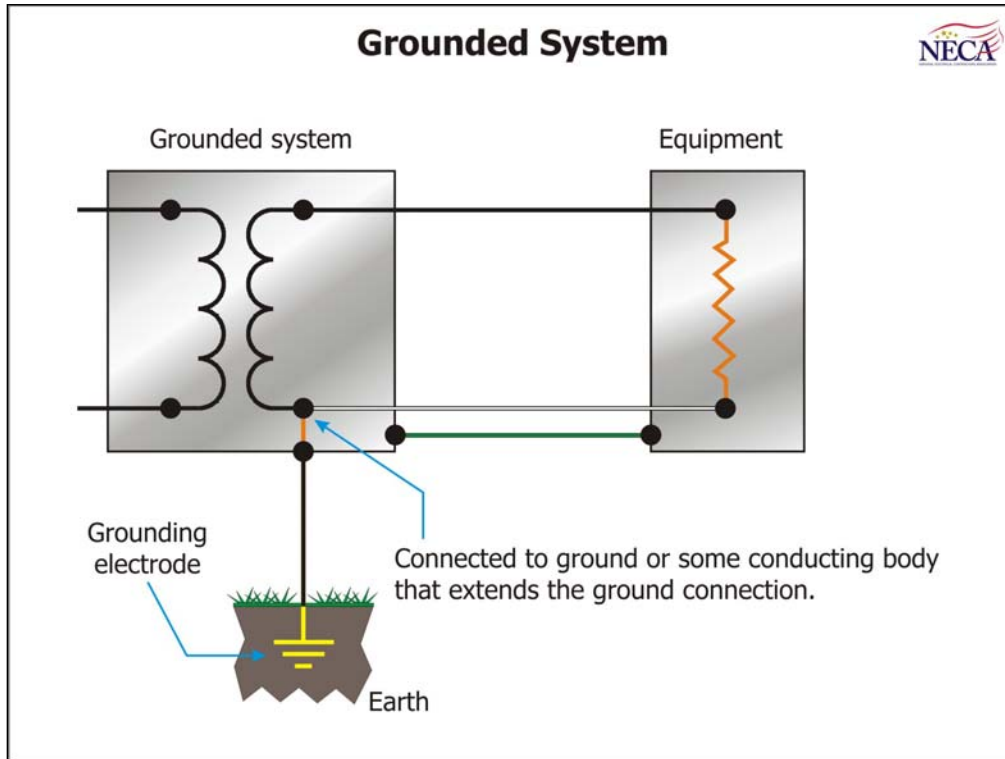


This slide shows an ungrounded system while the enclosures are grounded and bonded together.

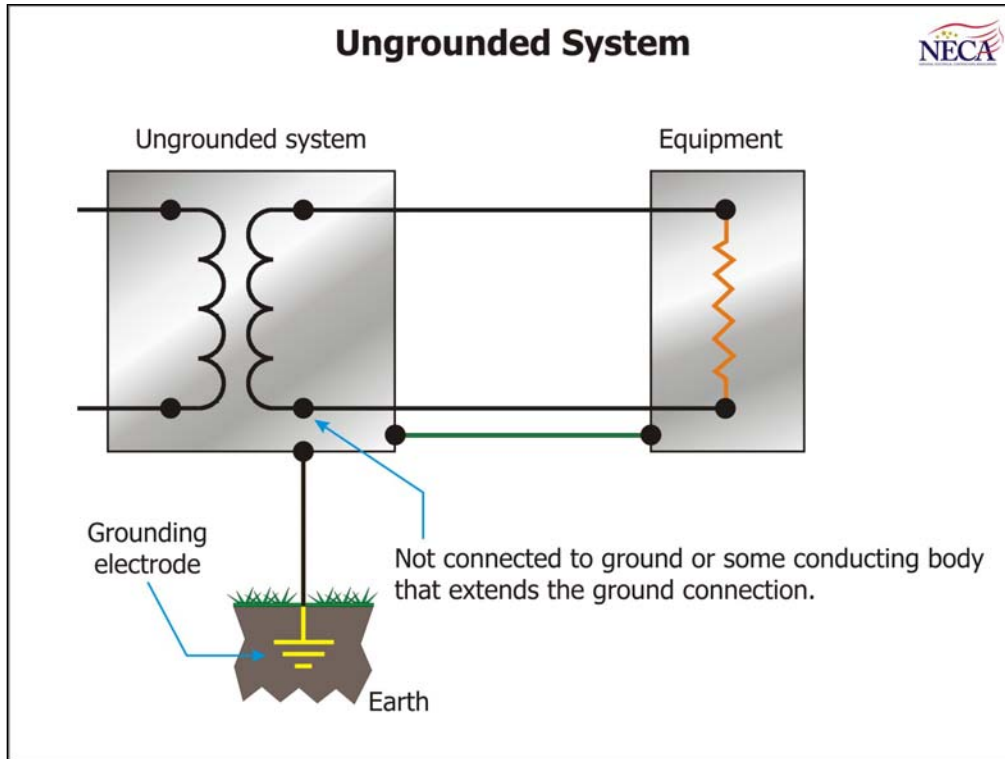
## System Grounding

- Section 250.20 provides systems that are required to be grounded.
- Section 250.21 covers systems that are not required to be grounded.
- Section 250.22 covers systems that are not permitted to be grounded.

System grounding requirements are provided in NEC Sections 250.20, 250.21, and 250.22. This slide just provides users with a brief review of the requirements for grounding systems.



System grounding implies that there is a conductor supplied by the system that is intentionally grounded. This creates a reference to ground potential from all other ungrounded (hot) conductors supplied by the system. Grounded systems offer the advantages of facilitating overcurrent device operation upon a first phase-to-ground fault.



The ungrounded system does not include a system conductor that is intentionally grounded. Grounding is still a requirement for conductive enclosures and raceways that enclose equipment and conductors supplied by the ungrounded system. Note that ungrounded systems are required to be provided with ground detection systems.

## Conductor to be Grounded

- Section 250.26 indicates which conductor of grounded systems is required to be grounded.
  - Single-phase, 2-wire — one conductor
  - Single-phase, 3-wire — the neutral conductor
  - Multiphase systems having one wire common to all phases — the common conductor
  - Multiphase systems where one phase is grounded - one phase conductor
  - Multiphase systems in which one phase is used as in (2) - the neutral conductor

Section 250.26 of the NEC includes guidance for users about which conductor of grounded systems is required to be the grounded conductor.

## Overcurrent Device Operation

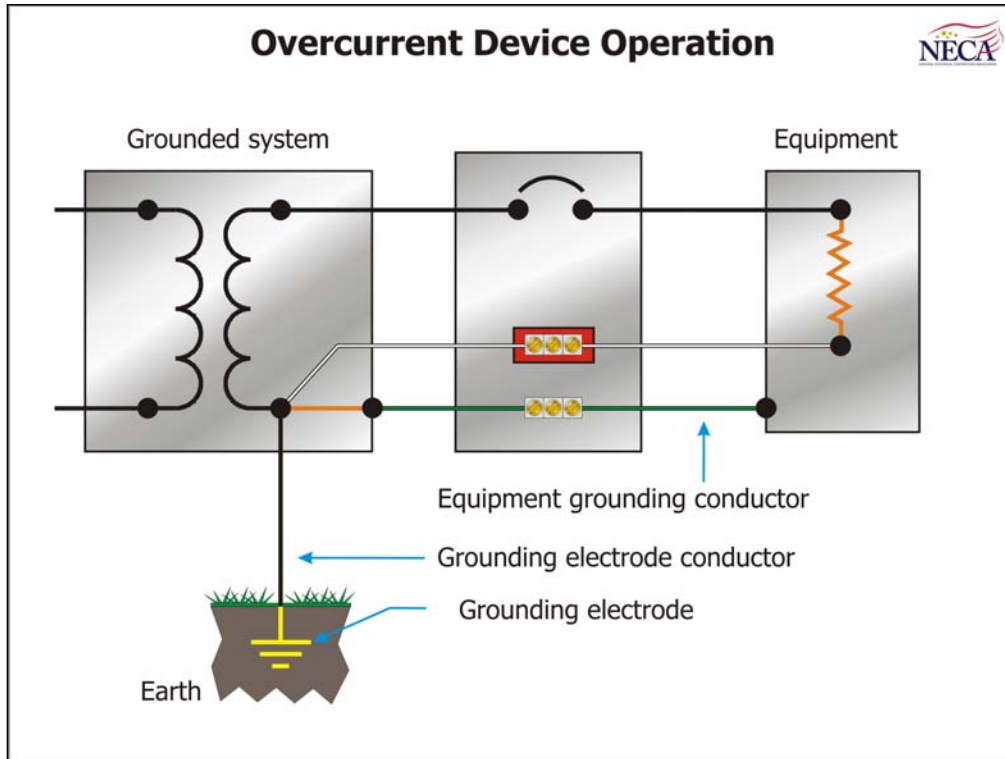
- Equipment grounding conductors and the process of bonding are related to constructing an effective ground-fault current path.
- Workmanship is important in constructing an effective ground-fault current path.

The equipment grounding conductor is an important component in the effective ground-fault current path. It is important to emphasize the value of good workmanship in electrical installations. The NECA National Electrical Installation Standards (NEIS) provide criteria about what constitutes good workmanship in electrical contracting. Tight setscrews and fittings and properly secured and supported raceways are all elements of good workmanship that result in constructing an effective ground-fault current path.

## Effective Ground-Fault Current Path

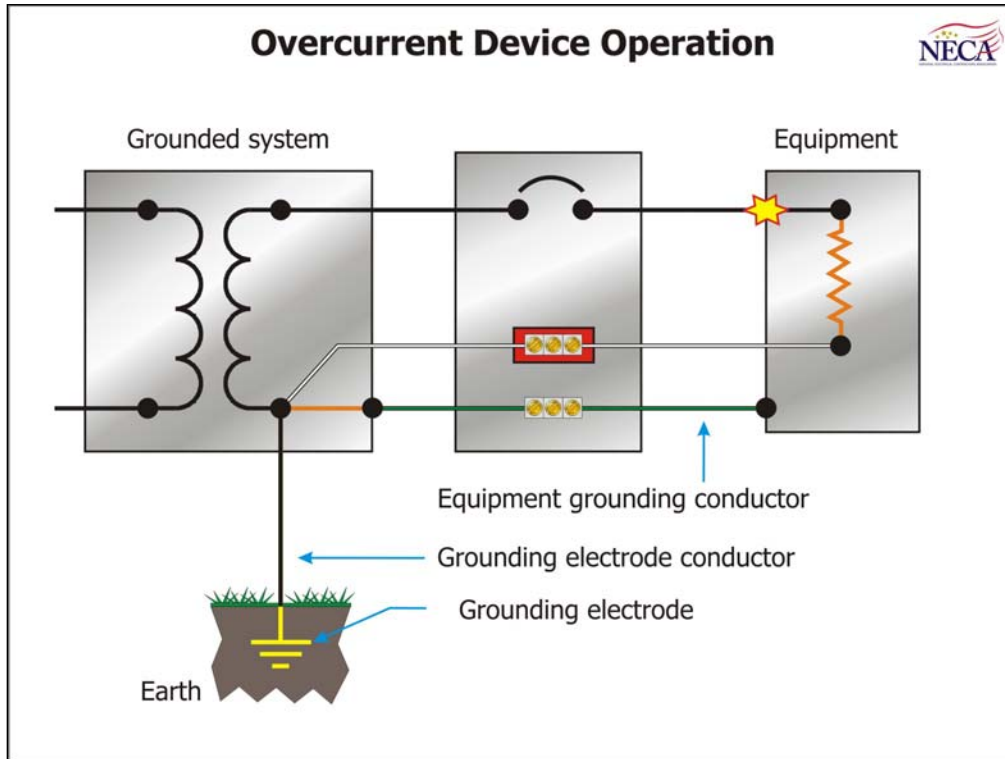
- An intentionally constructed by field installation
- Low-impedance electrically conductive path
- Designed and intended to carry current under ground-fault conditions from the point of a ground fault on a wiring system to the electrical supply source
- Facilitates the operation of the overcurrent protective device or ground-fault detectors on high-impedance grounded systems.
- *NEC 250.4(A)(5)*

Section 250.4(A)(5) provides specific characteristics of an effective ground-fault current path. This path must have as low an impedance as possible, be electrically continuous, and carry the maximum fault current likely to be imposed on it.

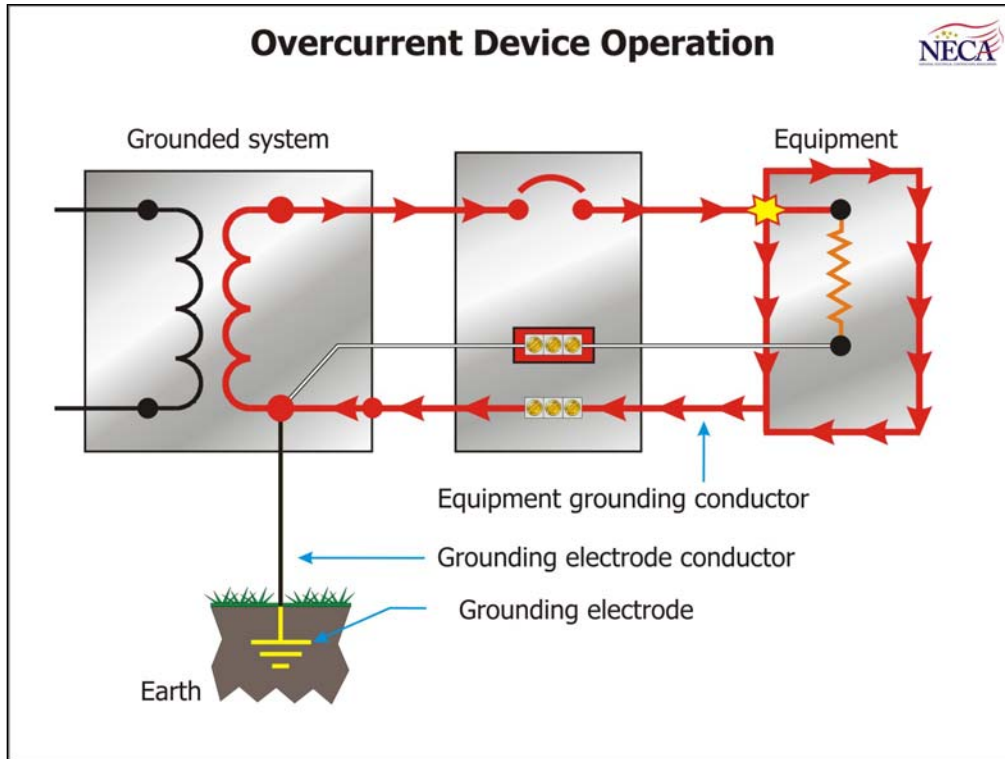


The next four slides provide a graphic representation of how overcurrent devices operate in ground fault condition. A circuit breaker is shown in this illustration with no preference made to circuit breakers rather than fuses. Both products provide overcurrent protection.

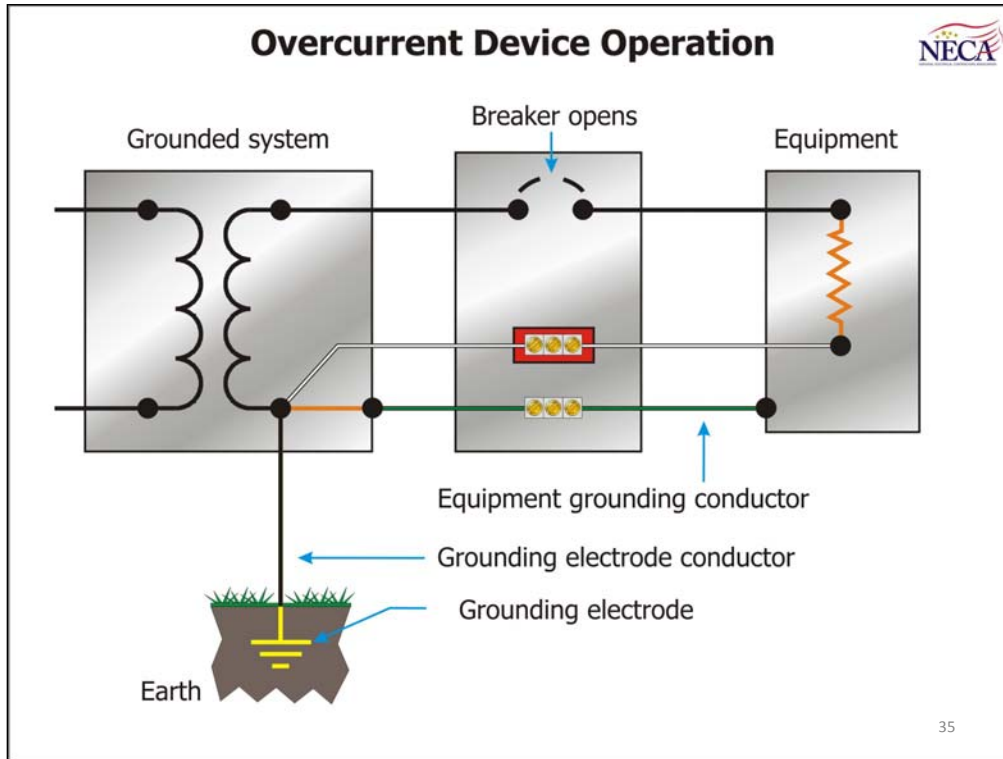




This slide shows a phase-to-ground fault condition from the ungrounded circuit conductor. This releases the maximum amount of fault current capable of being delivered by the supply system. This fault current will feed into the fault for as long as the condition exists while the overcurrent device is opening.



This slide shows the high amount of ground-fault current present in the effective ground-fault current path for a short time which causes the overcurrent device to open. The earth has little or no impact on the operation of overcurrent devices because it is such a high-impedance path in the circuit.



The fault is cleared when the circuit breaker opens. It is important that overcurrent devices and equipment be selected and coordinated to effectively clear a ground-fault event without causing extensive damage to the components of the circuit or system. [See NEC 110.9 and 110.10]

## Summary

- Grounding is making a connection to the earth.
- Bonding is connecting objects together (electrically).
- Grounding and bonding are inherent to electrical safety.
- Systems are installed grounded and ungrounded
- Equipment grounding conductors provide essential functions:
  - Connect equipment to ground
  - Perform bonding
  - Facilitate overcurrent device operation

This slide provides instructors an opportunity to review what was covered in the presentation. This short program provided the basics of electrical grounding and bonding and what is intended to be accomplished by both functions. Grounding means connecting to ground (earth). Bonding means connecting together. Equipment grounding conductors perform 3 essential functions: grounding of equipment, bonding, and serve as effective ground-fault current paths.



## Grounding and Bonding Fundamentals



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Take the opportunity to thank attendees for their participation and welcome them to join in the next NECA Webinar on Grounding Electrical Systems. This slide provides the transition to a short question and answer period following the Webinar.