Introduction

- This presentation is a representative sample from the following Chapters of Applied Grounding and Bonding.

- Chapter 1, Introduction
- Chapter 5, Requirements for Grounded Conductors at Services
- Chapter 13, Grounding and Bonding for Separately Derived Systems
- Chapter 11, Grounding at Separate Buildings or Structures
Introduction

- Basic grounding and bonding concepts and the related performance provisions contained in the National Electrical Code® (NEC®).
- Grounding and bonding are essential for safe electrical installations and systems.
- Mastering the subject of grounding and bonding requires understanding of what is intended to be accomplished by electrical grounding and bonding.

Objectives

- Recognize and understand key grounding and bonding terms
- Understand the role of the Earth in the electrical grounding system
- Understand the purpose of electrical grounding and bonding and fundamental grounding concepts of systems and equipment
- Understand fundamentals related to bonding and connecting conductive parts and equipment together to establish electrical continuity and conductivity
- Understand grounding and bonding concepts that perform together and simultaneously in electrical wiring systems
- Understand performance requirements for electrical grounding and bonding and application of NEC requirements

Grounding and Bonding For Safety

- The NEC provides minimum safety requirements that are intended to protect persons and property from hazards associated with the use of electricity.
- Grounding and bonding are necessary for safe electrical installations.
- One function complements and supports the other simultaneously.
- When non-current-carrying parts of equipment are bonded together and connected to ground, bonding and grounding are accomplished, enhancing safety in electrical systems.
Earth in the Circuit

- Grounding electrical equipment is an effective method of building safety into electrical systems.
- When an electrical system or electrical equipment is grounded, the earth is in the circuit.
- Grounded electrical systems and equipment offer the advantage of circuit protection by causing overcurrent devices to operate in a phase-to-ground fault condition.
- Equipment and systems that are grounded are connected to the earth through a grounding electrode(s).

Definitions

- The term "Ground" is defined in the NEC as "The earth."
- The term "Grounded (Grounding)" is defined in the NEC as "Connected (connecting) to ground or to a conductive body that extends the ground connection."
- Examples of conductive bodies that extend the ground connection are equipment grounding conductors and grounding electrode conductors.

Equipment Grounding

Grounded means connected to ground or to a conductive body that extends the ground connection.

A grounding electrode conductor is a conductive body extending the ground connection.
Ground is Earth

The term “ground” is defined as “the earth.”

The earth is a conductor, but a very poor current-carrying conductor.

The earth is in an electrical grounding circuit.

Grounding Process

Grounding is an ongoing process of connecting systems and equipment to the earth.

Bonding is inherent to the grounding process.

Bonding Concepts

- When two conductive objects such as metal boxes or other enclosures are connected together by metal conduit, bonding is accomplished.
- Bonding can also be accomplished by connecting metal parts together using wire bonding jumpers.
- When bonding is accomplished in power system installations, electrical continuity and conductivity is created between conductive materials and equipment.
Definition

• Bonded (Bonding). Connected to establish electrical continuity and conductivity. (NEC Article 100)

• Note: The definition uses the word connected indicating that connections are an integral function of bonding.

Minimizing Shock Hazards

• Grounding and bonding reduces potential differences between conductive parts and the Earth.

• The grounding and bonding process thereby reduce potential shock hazards.

• The NEC places significant emphasis of establishing an effective ground-fault current path.

• The purpose of this path is to facilitate overcurrent device operation and quickly remove faulted conditions from the system.
Purpose of Grounding

System grounding limits voltages imposed by:
- Lightning
- Line surges
- Unintentional contact with higher voltage lines

System and Equipment Grounding

System grounding compared to equipment grounding:
- Grounded system and equipment
- Ungrounded system, grounded equipment

Common Grounded System Voltages
Effective Ground-Fault Current Path

- The effective ground-fault current path is covered in Section 250.4(A)(5).
  - The path for current must be electrically continuous.
  - This path must also be of the lowest possible impedance.
  - This path also must be capable of carrying the maximum fault current likely to be imposed.
- The earth is not permitted as an effective ground-fault current path.

Normal Current Path

![Normal Current Path Diagram]

Effective Ground-Fault Current Path

![Effective Ground-Fault Current Path Diagram]
Summary

- Electrical grounding and bonding are actions that happen simultaneously and provide essential safety for persons and property.
- The performance criteria of these important electrical functions have are simple, yet to many they seem complex.
- Grounding involves connecting electrical systems and equipment to the Earth.
- Bonding is the process of establishing and maintaining effective continuity and conductive connections between metallic parts.
- The electrical safety system is heavily reliant upon effective grounding and bonding of equipment and systems.

Applied Grounding and Bonding

Chapter 5

Requirements for Grounded Conductors at Services

Introduction

- Premises wiring systems are typically supplied from a serving utility through conductors and equipment that make up an electrical service.
- Service equipment is required to be listed for service use and is made up of equipment enclosures that contain switches, circuit breakers, fuses, and other accessories.
- The service equipment is where the service conductors supplying the building or structure are connected.
- The first point of grounding and bonding for a premises wiring system typically occurs at or within the service equipment.
Objectives

• Understand the roles of the grounded conductor at the service equipment
• Determine the required grounding electrode conductor connection location(s) at the service equipment and outside the building or structure served
• Understand the installation and sizing requirements for the grounded conductor at services supplied by grounded systems
• Understand the physical characteristics and sizing requirements for main bonding jumpers in service equipment
• Understand the purpose of and location of the grounded conductor disconnecting means (neutral disconnecting link) in service equipment enclosures

Definitions

• Service. The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served. [NEC Article 100]

• Service Conductors. The conductors from the service point to the service disconnecting means. [NEC Article 100]

• Service Equipment. The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the load end of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply. [NEC Article 100]

• Grounded Conductor. A system or circuit conductor that is intentionally grounded. [NEC Article 100]
First Line of Defense

- The grounded system is typically a pad-mounted transformer or one or more transformers mounted on a utility pole.
- This is the usual location for the first system grounding connection of the system supplying the premises.
- The connection to ground is established either at the transformer pad or at the base of the pole.

Pole-Mounted Transformer

- The grounding connection for a pole-mounted transformer is a first line of defense or protection for premises wiring systems served by grounded utility sources.
- A single-phase, 3-wire grounded supply system is shown as a pole-mounted transformer bank.
Grounding Scheme for Services

- The grounding requirements on the load side of the service point are usually the responsibility of the electrical contractor and are accomplished when installing the service equipment.

- Installers must verify that the service equipment is marked indicating it is either “suitable for use as service equipment” or “suitable for use only as service equipment.” [NEC 230.66]

Grounding Connection Location

- The Code requires a grounding connection to be made at an accessible point anywhere from the load side of the service drop or lateral up to the service equipment enclosure.

- The grounding connection is typically made within the service equipment enclosure.

- The conductor used to accomplish the grounding is the grounding electrode conductor.

- Equipment that is suitable for use as service equipment is equipped with provisions for connecting a grounding electrode conductor.
Grounded Conductor Routing and Connections

- The grounded conductor is required to be [*routed*] to the service equipment and [*connected*] to the equipment enclosure. (NEC 250.24(C))
- This rule is one of paramount importance in the grounding and bonding scheme for service equipment.
- This requirement applies to services operating at less than 1000 volts.
- The connection of the grounded conductor to the service equipment enclosure is established through a *main bonding jumper*.

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Grounded Conductor Routing and Connections

- The grounded conductor must run to each service disconnecting means enclosure.
- The grounded conductor must be bonded to each service disconnecting means enclosure.
- **Main Bonding Jumper**
Main Bonding Jumper

- The main bonding jumper requirement applies to each service disconnecting means on the premises served, whether the service disconnecting means is a single main or is a group of service disconnects as permitted in Section 230.71.

- If up to six service disconnects are installed in separate enclosures, a main bonding jumper is required in each separate enclosure.

- An exception relaxes this requirement for listed service equipment that includes up to six service disconnects in a single enclosure.
Main Bonding Jumpers in Service Equipment

- The term main bonding jumper is defined in Article 100 as the connection between the grounded conductor and the equipment grounding conductor at the service.

- By definition, it is clear that this connection is made only at the service disconnecting means.

- Main bonding jumpers must be copper or other corrosion resistant material and can be in the form of a screw, bus, wire, or other suitable conductor.

- Where the main bonding jumper is a screw it must be identified using the color green.
The size for wire-type main bonding jumpers in each enclosure must be in accordance with Section 250.28(D)(1), which bases size on the largest ungrounded service conductor serving that individual enclosure.

- Use Table 250.66 or the 12.5% rule as appropriate for this sizing requirement.

### Main Bonding Jumper – Wire-Type

1. Service size: 400 amperes with aluminum service-entrance conductor sized at 750 kcmil aluminum:
   - Main bonding jumper 3/0 AWG aluminum minimum
   - Main bonding jumper 1/0 AWG copper minimum

2. Service size: 800 amperes with copper service-entrance conductor size (2) 600-kcmil conductors or one 1200-kcmil conductor:
   - Main bonding jumper 250 kcmil aluminum (minimum)
   - Main bonding jumper 3/0 AWG copper (minimum)
Listed Service Equipment

- Main bonding jumpers supplied with listed service equipment, such as switchboards and panelboards, can be installed without calculation of size.

- The manufacturer has built the equipment to meet or exceed the requirements in the applicable product safety standards, which includes grounding and bonding provisions.

Functions (Purposes) of the Grounded Service Conductor

- The grounded conductor at the service provides two essential functions for the premises wiring system.

- First, it is a current-carrying conductor for the load supplied.

- The grounded neutral conductors carry the unbalanced neutral current to the system neutral point.

- The grounded conductor of a service is usually a neutral conductor, but it may also be a phase conductor depending on the type of system.
Functions (Purposes) of the Grounded Service Conductor

- The second essential function of the grounded conductor is to perform as an effective ground-fault current path during ground-fault events at the service or at any point on the load side of the service equipment.

- The grounded conductor at the service is used for the intentionally constructed, low-impedance, effective ground-fault current path addressed in Section 250.4(A)(5).
Grounded Conductor Sizing Requirements

• The grounded service conductor is generally a current-carrying conductor during normal conditions but during abnormal conditions, it must be capable of carrying fault current.

• Therefore, it must meet minimum sizing requirements to ensure adequate capacity to serve both functions.

• The neutral conductor for services or feeders must have adequate capacity for the load served, as indicated in Section 220.61.

• Table 250.66 is also used to determine the minimum size required for service grounded conductors.

Minimum Size Examples

• The grounded conductor cannot be smaller than the required grounding electrode conductor using Table 250.66.

• This rule applies whether there is a load on the neutral or not.

• Example: 400-ampere service with 600 kcmil copper ungrounded service-entrance conductors requires a minimum 1/0 CU or 3/0 AL grounded conductor.

12.5% Rule Size Examples

• The 12.5% rule must be used for sizing the grounded conductor where the size of the largest ungrounded service conductor exceeds 1100-kcmil copper or 1750-kcmil aluminum or copper clad aluminum.

• Example: 800-ampere service with 1200 kcmil copper ungrounded service-entrance conductors (parallel 600 kcmil copper) requires a minimum 150 kcmil (calculated value) or rounded up to 3/0 AWG copper.
Grounded Conductor (Load Side Use)

- Section 250.24(A)(5) restricts load-side grounding connections to the grounded conductor; essentially connections on the load side of the service disconnecting means are not permitted.

- The same restriction is included for separately derived systems, as provided in Section 250.30(A).

- The informational notes following Sections 250.24(A)(5) and 250.30(A) indicate a few installations for which using the grounded conductor for grounding is permitted.

Neutral bus isolated from grounding bus

Separate the grounded conductor from ground on the load side of the service grounding point.
Summary

- A grounded conductor is required to be routed with the ungrounded service-entrance conductors, brought to each service disconnecting means enclosure, and connected to the enclosure.
- Grounded (often neutral) service conductors at the service cannot be smaller than that of the required grounding electrode conductor.
- The grounded conductor minimum size is determined based on the load served using Section 220.61; at a minimum it is sized using Table 250.66 or the 12.5% rule as required for larger services.
- Equipment used as service equipment is required to be listed and identified for such use.

Applied Grounding and Bonding

Chapter 13

Grounding and Bonding for Separately Derived Systems

Introduction

- Electrical wiring and power distribution systems for commercial, industrial, institutional, and even some residential occupancies typically include the installation and use of separately derived systems.
- Generally, a separately derived system is a separate power source, such as a generator, photovoltaic system, wind turbine, battery, or other source that produces electrical power. The secondary of a transformer is also a common example of a separately derived system, if it is not “directly connected to circuit conductors of another system”.
- The NEC® provides an extensive set of rules specifically related to grounding and bonding for separately derived systems.
- To understand and properly apply these rules to separately derived system installations, the meaning of certain terms must be clear.
Objectives

• Understand what constitutes a separately derived system as defined and how to distinguish them from systems that are not separately derived
• Determine NEC grounding and bonding requirements that apply to separately derived systems
• Understand the application of the common grounding electrode conductor tap concept for multiple separately derived systems
• Size grounding electrode conductors, system bonding jumpers, supply side bonding jumpers, and grounded conductors for a separately derived system
• Determine how to ground and bond a generator-type separately derived system
• Understand the relationship between the transfer equipment and the system grounding requirements for generator-type separately derived systems

Using Defined Terms

• The use of NEC terminology is important to determine which rules apply to installations and systems.
• A variety of “Code-defined” terms are used on the subject of grounding and bonding of separately derived systems.
• A common language of communication must be used when applying Code rules to any system or installation.

Definitions

• Bonded (Bonding). Connected to establish electrical continuity and conductivity. [NEC Article 100]
• Bonding Jumper, Supply-Side. A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected. [NEC 250.2]
Definitions

• Bonding Jumper, System. The connection between the grounded circuit conductor and the supply-side bonding jumper, or the equipment grounding conductor, or both, at a separately derived system. [NEC Article 100]

• Grounded (Grounding). Connected (connecting) to ground or to a conductive body that extends the ground connection. [NEC Article 100]

• Grounding Electrode. A conducting object through which a direct connection to earth is established. [NEC Article 100]

Definition

• 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. [NEC Article 100]

• Separately Derived System. A premises wiring system whose power is derived from a source of electric energy or equipment other than a service. Such systems have no direct connection from circuit conductors of one system to circuit conductors of another system, other than connections through the earth, metal enclosures, metallic raceways, or equipment grounding conductors. [NEC Article 100]

Determining a Separately Derived System

• One of the keys to determining whether or not a system is separately derived has to do with it not having a “direct electrical connection” to the circuit conductors of another source. See the definition full for clarification.

• Examples of separately derived systems include generators, batteries, converter windings, transformers, solar photovoltaic systems, and wind turbine generators.

• Common separately derived systems installed in premises wiring installations include transformers and generators.
Some transformers do not qualify as separately derived systems because one winding in the transformer is common to both the input and the output side of the transformer.

These are autotransformers addressed by requirements in Article 450.

Examples of autotransformers are a core and coil ballast in a fluorescent luminaire and a "buck-boost" transformer used for raising or lowering voltage levels for a particular application or single piece of utilization equipment.

Grounded conductor is common to both the input and output.
Grounding Requirements

- Grounding a separately derived system means that the system itself will be connected to the Earth, in addition to the enclosure containing the system, if applicable.
- The grounding connection happens through a grounding electrode.
- When a system is connected to the Earth, one conductor supplied by the system is intentionally grounded.
- The grounded conductor is usually a neutral supplied by the system, but it could be grounded phase conductor.

Grounded Systems

- If a separately derived system is required to be grounded, based on the provisions in Section 250.20 or 250.21, the rules in Sections 250.30(A)(1) through (8) apply.
- There are some components that are common to the grounding and bonding scheme of a typical separately derived system.
- The following illustration shows the typical grounding and bonding components of a single-phase, transformer-type separately derived system.
The system bonding jumper of a separately derived system connects the grounded conductor of the system to the enclosure, to the supply-side bonding jumper, to the grounding electrode conductor, and to an equipment grounding conductor (EGC) if there is a primary supply to a transformer-type derived system.

See the definition of the term system bonding jumper for clarification as to its location in the grounding scheme for separately derived systems.

The system bonding jumper can be located at any point from the source enclosure up to the first system overcurrent device or disconnecting means.

If there is no disconnecting means or overcurrent device at the load end of the conductors supplied by the system, the system bonding jumper must be installed in the source enclosure.

In transformers, the system bonding jumper connection is made typically in the source enclosure.

The system bonding jumper is not permitted to extend beyond the enclosure where it originates.
System Bonding Jumper Connections

- Where the system bonding jumper is installed in the source enclosure, it must connect the **grounded conductor** to the supply-side bonding jumper and to the metal enclosure.

- If the system bonding jumper is installed at the first disconnecting means enclosure, it must connect the **grounded conductor** to the supply-side bonding jumper, to the disconnecting means enclosure, and to the EGC(s).
System Bonding Jumper Connections

- Note that for a transformer-type separately derived system there is usually an EGC with the primary feeder connection and a supply-side bonding jumper with the secondary connection.

- These two are connected to the source enclosure.

System Bonding Jumper Size

- The system bonding jumper must be installed according to Sections 250.28(A) through (D).

- Where a system bonding jumper is a wire type, it is sized using Table 250.66 or the 12.5% rule based on the size of the largest ungrounded derived phase conductor or conductors or the total circular mil (cm) area of all conductors connected to any one ungrounded phase at the source.
Bonding between the transformer (source) enclosure and the first system overcurrent device enclosure can be accomplished using a metallic wiring method that qualifies as an EGC according to 250.118.

A wire-type supply-side bonding jumper is required to be sized in accordance with Section 250.102(C) based on the size of the largest derived phase conductor connected to the system.

The supply-side bonding jumper is not required to be larger than the derived phase conductors supplied by the system.
Grounded Conductor Sizing

• The grounded conductor sizing requirements are located in Sections 220.61 and 250.30(A)(3).

• If the system bonding jumper is not located at the source enclosure, the grounded conductor of the separately derived system must meet specific sizing requirements.

• Where installed in a single raceway with the ungrounded phase conductors, the grounded conductor cannot be smaller than the required grounding electrode conductor based on Table 250.66, but it is not required to be any larger than the largest ungrounded derived phase conductor.

Grounded Conductor Sizing

• For ungrounded derived phase conductors exceeding the values in Table 250.66, the grounded conductor cannot be smaller than 12.5% of the circular mil area of the largest ungrounded conductor or set of ungrounded conductors per phase.

• If the ungrounded derived phase conductors of a system are installed in a parallel arrangement, using two or more raceways, the grounded conductor must be installed in parallel in each raceway.

Grounding Electrodes

• Section 250.30(A)(4) is specific about the electrode that must be used for grounding a separately derived system.

• An order of selection is established by the requirements in the Code; it is not a matter of choice in many cases.

• It must be as near as practicable and preferably in the same area as the system being grounded.

• The grounding electrode must be the nearest of either a metal water pipe electrode or a structural metal electrode.
If there is no water pipe electrode or structural metal building frame electrode, then a grounding electrode must be established.

By exception, any of the other grounding electrodes in Section 250.52(A) can be used in this case.

Remember that this is only permitted if the electrodes addressed in 250.30(A)(1) or (2) are not available (present) for use.

For a single separately derived system, the grounding electrode conductor generally has to be sized using Section 250.66 based on the size of the largest ungrounded derived phase conductors.

The grounding electrode conductor has to connect the grounded conductor of the system to the grounding electrode described in Section 250.30(A)(4).

The connection of the grounding electrode conductor to the system must be made where the system bonding jumper is installed.

- Same location
The common grounding electrode conductor tap method can be used for grounding multiple separately derived systems using 250.30 (A)(6).

The single common grounding electrode conductor sized no less than 3/0 AWG copper or 250 kcmil aluminum.

Each tap conductor must be sized using Table 250.66 based on the largest ungrounded derived phase conductor(s) of the individual derived system is serves.
Grounding Electrode Conductor for Multiple Systems

• The connections of the grounding electrode conductor tap to the common grounding electrode conductor have to be made at an accessible location.

The connections can be made by:
• an exothermic welding process,
• a connector listed as grounding and bonding equipment, or
• listed connections to a ¼ in. x 2 in. copper or aluminum busbar.

Grounding Electrode Conductor for Multiple Systems

• The connection between the tap and the common grounding electrode conductor has to be made in a way that the common grounding electrode conductor remains without a splice or joint.

• The grounding electrode conductors for separately derived systems must be installed in accordance with Sections 250.64(A) through (C) and (E).
Section 250.104(D) provides bonding requirements for metal water piping systems and structural steel that are in the same areas served by the separately derived system.

The size of the bonding jumper for both the water piping and the structural steel must be in accordance with Table 250.66 based on the largest ungrounded conductor supplied by the separately derived system.

The bonding jumper must be connected to the grounded conductor of the separately derived system in the same location where the system bonding jumper for the derived system is located.
Outdoor Source

• If the source is located outside the building or structure it supplies, a grounding electrode connection to the source is required at the source location outside the building or structure. See 250.30(C).

• The grounding electrode used for this connection to the Earth has to be in accordance with Section 250.50.

• This means that if any of the electrodes in Sections 250.52(A)(1) through (7) are present for use, they have to be used for this grounding connection.

Generators and Transfer Equipment

• The grounding and bonding connections for a generator are usually determined by the type of transfer equipment installed.

• If a transfer switch for a generator includes a switching action in the grounded conductor, then the generator is a separately derived system.

• The requirements in Section 250.30(A) apply to the generator in this case, since it is the separately derived system source.
• Where the transfer switch includes switching of the grounded conductor, the generator has to be grounded as a separately derived system.

• The installation instructions provided with the transfer equipment provide important information related to use of the transfer switch.
**Generator Not Separately Derived**

- If there is **no switching action** in the grounded conductor by the transfer equipment, then the generator system is grounded with the transfer switch in either position.

- The system grounding relies on the grounded conductor connection to the earth through a grounding electrode conductor connected at the service equipment.

- The grounding and bonding connections in this case have to meet the requirements in Section 250.35 for permanently installed generators.

**Generators with Overcurrent Protection**

- Where an overcurrent device is installed at the generator, an EGC is installed with the generator conductors to the first enclosure supplied by the system.

- This an EGC is required to be sized using Table 250.122, based on the rating of the overcurrent device installed on the generator.
Generators without Overcurrent Protection

- If overcurrent protection is **not provided** at the generator, a **supply-side bonding jumper** must be installed between the generator equipment grounding terminal and the equipment grounding terminal bar or bus of the enclosure supplied by the system.

- If the bonding jumper is on the supply side of the first system overcurrent device, it is sized as a supply-side bonding jumper in accordance with Section 250.102(C).

- Use Table 250.66 or the 12.5% rule for sizing supply-side bonding jumpers.
Small Wind Electrical System

- Small wind electrical systems are covered by Article 694 of the NEC.
- The article is made up of nine parts.
- Part V provides specific grounding and bonding rules for these systems.
Summary

- Separately derived systems can be in the form of a transformer, generator, inverter windings, photovoltaic array, and so forth.
- System grounding requirements are provided in Part II of NEC Article 250.
- Whether or not a system is required to be grounded is specified in Section 250.20.
- When a system is required to be grounded, the rules in Section 250.30(A) have to be applied.
- Specific requirements in Section 250.30(B) that apply to ungrounded separately derived systems.
- Part VIII of Article 250 provides specific rules for DC systems that must be grounded.

Applied Grounding and Bonding

Chapter 11

Grounding at Separate Buildings or Structures

Introduction

- At some properties, a single utility service supplies multiple buildings or structures.
- The service directly supplies one of the buildings, and feeders or branch circuits supply other buildings from that service equipment.
- Alternatively, the utility service can be freestanding, such as on a pole, and feeders or branch circuits supply all buildings or structures.
- Specific grounding and bonding rules apply to separate buildings or structures supplied by feeders or branch circuits.
Objectives

• Determine the requirements for a grounding electrode system at buildings or structures supplied by a branch circuit(s) or feeder(s)
• Understand the requirements for equipment grounding conductors to be installed with feeders or branch circuits supplying separate buildings or structures
• Understand the exception for grounded conductors used for equipment grounding at a separate building or structure supplied by a feeder or branch circuit
• Determine the bonding requirements for metal water piping systems and structural metal building framing of separate buildings or structures
• Understand the grounding and bonding rules associated with generators supplying separate buildings or structures

Grounding Rules for Separate Buildings

• The requirements for grounding and bonding at separate buildings or other structures are located in Part III of NEC® Article 250.
• Section 250.32 provides specific requirements for grounding and bonding at separate buildings or structures supplied by a feeder(s) or branch circuit(s).
• A grounding electrode or grounding electrode system is generally required at separate buildings supplied by feeder(s) or branch circuit(s).

Definitions

• Branch Circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). [NEC Article 100]
• Branch Circuit, Multiwire. A branch circuit that consists of two or more ungrounded conductors that have a voltage between them, and a grounded conductor that has equal voltage between it and each ungrounded conductor of the circuit and that is connected to the neutral or grounded conductor of the system. [NEC Article 100]
Definitions

- Building. A structure that stands alone or that is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors. [NEC Article 100]

- Feeder. All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device. [NEC Article 100]

- Grounding Electrode. A conducting object through which a direct connection to earth is established. [NEC Article 100]

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Definitions

- 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. [NEC Article 100]

- Structure. That which is built or constructed. [NEC Article 100]

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Supplying Power to Separate Buildings or Structures

- A service, by definition is supplied from an electric utility.

- If the supply is from a transformer or generator that is customer owned, it is not a service and therefore is a feeder or branch circuit.

- Section 250.32 provides the requirements for grounding and bonding at separate buildings or structures that are supplied by other than a service.

- These types of installations are fairly common in residential, commercial, and industrial applications.
Purpose of Grounding and Bonding at Separate Buildings or Structures

• The purpose of grounding and bonding systems at branch circuit or feeder supplied separate buildings or structures is similar to service supplied buildings or structures.

• A connection to ground is required at separate buildings or structures to establish a reference to ground at that location.

• This places all normally conductive non-current-carrying metal parts and other conductive materials at or as close as possible to Earth potential.
Grounding Electrode Required

- A **grounding electrode system** is generally required at a separate building or structure supplied by feeders or branch circuits.

- This condition is relaxed by exception under either of the following conditions:
  1. The building or structure is not supplied by electrical power
  2. The structure or building is supplied by a single branch circuit (including multiwire branch circuit) that includes an equipment grounding conductor (EGC) for grounding non-current-carrying parts of equipment. [NEC 250.32(A) Exc.]

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Grounding Electrode System

- Section 250.32(A) provides the general requirement for a grounding electrode system in accordance with Part III of Article 250.

- The grounding electrode requirements in Section 250.50 must be applied to separate buildings or structures supplied by feeders or branch circuits.

- If any of the grounding electrodes in Section 250.52(A) are present (exist) at the building or structure served, they must be bonded together to form a grounding electrode system for the separate building or structure.

- If no grounding electrodes are present to form a grounding electrode system at the separate building or structure, one must be installed.
Section 250.32(E) provides requirements for the grounding electrode conductor installations at separate buildings or structures supplied by feeders or branch circuits.

Part III of Article 250 provides the requirements for grounding electrode conductor installation and sizing.

The grounding electrode conductor is generally sized according to Table 250.66, which bases sizing on the largest ungrounded circuit conductor supplying the building or structure.

See also 250.66(A), (B), and (C) for sole connections to the electrodes specified in those sections.
Feeder and Branch Circuit Requirements

- Feeders are generally required to include an equipment grounding conductor, as indicated in Section 215.6.

- When feeders or branch circuits are installed to supply a separate building or structure, an EGC must also be installed.

- The EGC can be a wire type, or it can be any wiring method in Section 250.118 that qualifies as an EGC. If the EGC is a wire type, the minimum size must be in accordance with Section 250.122.
One Exception to 250.32(B)

• The grounded (usually the neutral) conductor of feeders or branch circuits is permitted to be used for grounding at separate buildings or structures only in existing installations in compliance with previous editions of the NEC, and only under the following conditions:

1. An EGC is not included with the supply circuit to the separate building or structure.
2. There are no common electrically continuous metallic paths between the feeder source and the destination at the building or structure served.
3. Ground-fault protection of equipment is not provided on the supply side of the feeder.
Supplied by Separately Derived Systems

- Section 250.32(B)(2) addresses buildings or structures supplied by separately derived systems, such as transformers or generators installed outside the building or structure.

- This rule provides rules for sizing equipment grounding conductors or supply-side bonding jumpers installed with a feeder(s) installed from a separately derived system(s) for supplying a separate building or structure.

Systems with Overcurrent Protection

- If overcurrent protection is provided where the conductors originate, the installation of a feeder or branch circuit to a separate building or structure has to include an EGC in accordance with Section 250.32(B)(1).

- Size the EGC with the feeder in accordance with Section 250.122.
Systems without Overcurrent Protection

- If overcurrent protection is not provided where the conductors originate, at the separately derived system source, the installation must comply with Section 250.30(A).
- Where installed with the feeder to the building or structure, the supply-side bonding jumper must be connected to the building or structure disconnecting means and to the grounding electrode system.
- The supply-side bonding jumper is sized according to 250.102(C) and sized according to 250.66.

Separately derived system without overcurrent protection
Building disconnect

Feeder with supply-side bonding jumper
Grounding electrodes required

Summary

- Specific electrical grounding and bonding requirements are provided in NEC 250.32 and apply to buildings or structures supplied by feeders or branch circuits.
- A grounding electrode system is generally required at separate buildings or structures supplied by a feeders or branch circuits.
- Generally, the grounded conductor must be separated and isolated from ground, the grounding electrode, and the EGC at separate buildings or structures.
- Whether supplied from a grounded system or ungrounded system, specific grounding and bonding rules must be applied at separate buildings or structures.
Applied Grounding and Bonding

Questions

Thank You For Attending