

# Grounding and Bonding

3 Days, 2.1 CEUs

Proper grounding and bonding of electrical equipment helps ensure that the electrical equipment and systems safely remove the possibility of electric shock, by limiting the voltage imposed on electrical equipment and systems from lightning, line surges, unintentional contact with higher-voltage lines, or ground-fault conditions. Proper grounding and bonding is important for personnel protection, as well as for compliance with OSHA 29 CFR 1910.304(g) Grounding.

This course focuses on the grounding and bonding requirements contained in Article 250 of National Electrical Code®. Article 250 identifies grounding and bonding system installation methods. Specific topics that are addressed include, but are not limited to: definitions; grounded (neutral) conductor requirements; sizing equipment grounding conductors, equipment bonding jumpers, grounding electrode conductors, and main bonding jumpers; identifying types of grounding electrodes; requirements for multiple grounding electrodes; bonding requirements for non-electrical equipment; the purpose of impedance or resistance grounding; requirements for an isolated grounding system; and grounding and bonding requirements for the line side and the load side of the service disconnecting means.

AVO provides an outdoor training yard for grounding electrode resistance testing and earth resistance testing. On-site training of this course requires the site facility to provide an adequate test area for the performance of these tests.

This hands-on course is intended for new or experienced electricians and technicians that install, maintain, repair or troubleshoot power and auxiliary systems. The participant should have basic knowledge of power system components.

## Lab and Classroom Attire

AVO is committed to the personal safety of each participant and requires long pants and ANSI rated "safety toe" work shoes for class and lab activities. Lecture courses may involve a tour of a work or shop area and for this reason open toe shoes and shorts are not considered appropriate attire for the classroom.

## Learning Objectives

To receive 2.1 CEUs, participants must attend 3 days of class (21 contact hours) and attain a minimum average grade of 80% (overall grade will consist of 50% lab practice and 50% final exam). Upon completion of this course and lab practice, the participant will demonstrate that he/she is able to:

- Explain the fundamentals, basic principles, and requirements of grounding and bonding.
- Identify and utilize grounded conductors.
- Summarize ground-fault circuit interrupter requirements.
- Select the appropriate grounding system and discuss the implications.
- Outline grounding electrode systems and their requirements.
- Describe the requirements for the installation of equipment grounding and bonding conductors.

## SCOPE

### Day 1 (7 contact hours)

- I. Introduction (0.5 hour)
  - A. Schedule
  - B. Course Outline
- II. Fundamentals of Grounding and Bonding (1 hour)
  - A. Basic Electrical Concepts
  - B. Hazards of Electricity
  - C. Definitions
  - D. Student Exercise – Code Search Definition

- III. Basics of Grounding and Bonding (1 hour)
  - A. Grounding and Bonding
  - B. Grounding versus Bonding
  - C. Student Exercise – Identifying Grounding, Bonding, and Grounded Components

#### AM BREAK

- IV. Use and Identification of Grounded Conductors (1.5 hours)
  - A. General
  - B. Connection To Grounded System

- C. Neutral Conductors
- D. Means of Identifying Grounded Conductors
- E. Use of Insulation of a White or Gray Color or with Three Continuous White or Gray Stripes
- F. Means of Identification of Terminals
- G. Identification of Terminals
- H. Polarity of Connections
- I. Student Exercise – Drawing In and Identifying Electrical System Components

LUNCH

\*Class scheduling times may vary based on discussions and size of class

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## SCOPE (continued)

- V. Ground-Fault Circuit-Interrupter Requirements (1.5 hour)
  - A. Ground-Fault Circuit Interrupter Protection for Personnel
  - B. Student Exercise – Identifying Where GFCI Protection Is Required

### PM BREAK

- VI. General Requirements (1.5 hours)
  - A. General Requirements for Grounding and Bonding
  - B. Objectionable Current
  - C. Connection of Grounding and Bonding Equipment
  - D. Protection of Ground Clamps and Fittings
  - E. Clean Surfaces
  - F. Exercise – Identifying Grounded & Ungrounded Systems
  - G. Exercise – Identifying All System Power Distribution G&B Components

### Day 2 (7 contact hours)

- VII. System Grounding (2 hours)
  - A. Alternating-Current Systems To Be Grounded
  - B. Alternating-Current Systems of 50 Volts To Less Than 1000 Volts Not Required To Be Grounded
  - C. Circuits Not To Be Grounded
  - D. Grounding Service-Supplied Alternating-Current Systems
  - E. Conductor To Be Grounded – Alternating-Current Systems
  - F. Main Bonding Jumper and System Bonding Jumper
  - G. Grounding Separately Derived Alternating-Current Systems

### AM Break

- H. Buildings or Structures Supplied by a Feeder(s) or Branch Circuit(s)
- I. Portable and Vehicle-Mounted Generators
- J. Permanently Installed Generators
- K. High-Impedance Grounded Neutral Systems
- L. Student Exercise – Calculating the Size of Equipment, Transformer, Supply Side, and Separately Derived System Bonding Jumpers

### Lunch

- VIII. Grounding Electrode System and Grounding Electrode Conductor (5 hours)

- A. Grounding Electrode System
  - B. Grounding Electrodes
  - C. Grounding Electrode System Installation
    - 1. Lab 1 – Earth Resistivity
    - 2. Lab 2 – Earth Fall-of Potential
- PM Break
- D. Auxiliary Grounding Electrodes
  - E. Common Grounding Electrode
  - F. Use of Strike Termination Devices
  - G. Grounding Electrode Conductor Installation
  - H. Size of Alternating-Current Grounding Electrode Conductor
  - I. Grounding Electrode Conductor and Bonding Jumper Connection To Grounding Electrodes
  - J. Methods of Grounding and Bonding Conductor Connection To Electrodes
  - K. Student Exercise – Determining the Size of the Grounding Electrode Conductor

### Day 3 (7 contact hours)

- IX. Bonding (2 hours)
  - A. General
  - B. Services
  - C. Bonding for Communication Systems
  - D. Bonding Other Enclosures
  - E. Bonding for Over 250 Volts
  - F. Bonding Loosely Jointed Metal Raceways
  - G. Bonding in Hazardous (Classified) Locations
  - H. Grounded Conductors, Bonding Conductors and Jumpers
  - I. Bonding of Piping Systems and Exposed Structural Metal
  - J. Lightning Protection Systems
  - K. Student Exercise – Calculating the Size of the Feed Conductor, Conduit, Grounding Electrode Conductor, Grounded Conductor, and Main Bonding Jumper

### AM Break

- X. Equipment Grounding and Equipment Grounding Conductors (2 hours)
  - A. Equipment Fastened in Place (Fixed) or Connected by Permanent Wiring Methods
  - B. Specific Equipment Fastened in Place (Fixed) or Connected by Permanent Wiring Methods

- C. Nonelectrical Equipment
- D. Types of Equipment Grounding Conductors
- E. Identification of Equipment Grounding Conductors
- F. Equipment Grounding Conductor Installation
- G. Use of Equipment Grounding Conductors
- H. Size of Equipment Grounding Conductors
- I. Equipment Grounding Conductor Continuity
- J. Identification of Wiring Device Terminals
- K. Student Exercise – Calculating the Size of Conduit for Various Conductors in Different Types of Conduit
- L. Student Exercise – Calculating What the Minimum Size for the Equipment Grounding Conductor is Based on the Feeder Conductor Increase in Size Due to Excess Voltage Drop

### Lunch

- XI. Methods of Equipment Grounding (2 hours)
  - A. Equipment Grounding Conductor Connections
  - B. Short Sections of Raceway
  - C. Equipment Fastened in Place or Connected by Permanent Wiring Methods (Fixed) – Grounding
  - D. Equipment Considered Grounded
  - E. Cord- and Plug-Connected Equipment

### PM Break

- F. Frames of Ranges and Clothes Dryers
- G. Use of Grounded Circuit Conductor for Grounding Equipment
- H. Multiple Circuit Connections
- I. Connecting Receptacle Grounding Terminal To Box
- J. Continuity and Attachment of Equipment Grounding Conductors To Boxes

### XII. Conclusion (1 hour)

- A. Course Review
- B. Final Exam