

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 participants will demonstrate that they are 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. Identification of Terminals
- F. Polarity of Connections
- G. Student Exercise – Drawing In and Identifying Electrical System Components

LUNCH

- V. General Requirements (1.5 hours)
 - A. General Requirements for Grounding and Bonding
 - B. Objectionable Current
 - C. Connection of Grounding and Bonding Equipment

PM BREAK

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

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SCOPE (continued)

- 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)

- VI. System Grounding (2 hours)
 - A. Alternating-Current (AC) Systems to be Grounded
 - B. AC Systems of 50V to less than 1000V not required to be Grounded
 - C. Circuits not to be Ground
 - D. AC Systems Grounding Service-Supplied
 - E. AC Systems Conductor to be Grounded
 - F. Main Bonding Jumper and System Bonding Jumper
 - G. Grounding Separately Derived AC Systems

AM Break

- H. Buildings or Structures Supplied by a Feeder(s) or Branch Circuit(s)
- I. 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

- VII. Grounding Electrode System and Grounding Electrode Conductor (5 hours)
 - A. Grounding Electrode System
 - B. Installation
 - Lab 1 – Earth Resistivity
 - Lab 2 – Earth Fall-of Potential

PM Break

- C. Auxiliary Grounding Electrodes
- D. Common Grounding Electrode
- E. Use of Strike Termination Devices
- F. Grounding Electrode Conductor Material, Installation and Sizing
- G. Grounding Electrode Conductor and Bonding Jumper Connection to Grounding Electrodes
- H. Methods of Grounding and Bonding Conductor Connection to

Electrodes

- I. Student Exercise – Determining the Size of the Grounding Electrode Conductor

Day 3 (7 contact hours)

VIII. 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

- IX. Equipment Grounding and Equipment Grounding Conductors (2 hours)
 - A. Equipment Fastened in Place (Fixed) or Connected by Permanent Wiring Methods
 - B. Equipment Connected by Cord and Plug
 - C. Nonelectrical Equipment
 - D. Types and Identification of Equipment Grounding Conductors
 - E. Equipment Grounding Conductor Installation
 - F. Use and Size of Equipment Grounding Conductors
 - G. Equipment Grounding Conductor Continuity
 - H. Identification of Wiring Device Terminals
 - I. Student Exercise – Calculating the Size of Conduit for Various Conductors in Different Types of Conduit
 - J. 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

- X. 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
- XI. Conclusion (1 hour)
 - A. Course Review
 - B. Final Exam



STANDARD EQUIPMENT LIST

Grounding and Bonding

REVISED: September 2020

COURSE NO. 417B REV 5

BY: Ron Vanwart

DAYS: 3

TEXT (PER 1 STUDENT)	
1	<i>GROUNDING AND BONDING</i> COURSE NO. 417B REV5, SEPTEMBER 2021

MATERIALS NEEDED (PER CLASSROOM)	
QUANTITY	ITEM
*1	PROJECTOR OR TV WITH PROJECTION CAPABILITIES
*1	DRY ERASE BOARD WITH MARKERS AND ERASERS
*10	STUDENT TABLES
*10	STUDENT CHAIRS

EQUIPMENT (PER STUDENT)	
QUANTITY	ITEM
1	NEC 2020 (DESK COPIES TO BE RETURNED)
1	CALCULATOR (TO BE RETURNED)
1	SMALL BOX OF COLORED PENCILS

EQUIPMENT (PER CLASS)	
QUANTITY	ITEM
1	EARTH RESISTANCE TEST SET DET 2/2 OR DET 5/4 W/4 TEST RODS & 4 CABLES (TEST SET MUST HAVE 4 TERMINALS)
1	GROUND RESISTANCE CLAMP TEST SET (DET 10C OR 20C)
1	DLRO
1	100 FOOT TAPE MEASURE
1	SHOP HAMMER (MUST BE HEAVY ENOUGH TO DRIVE TEST RODS)
2	SAFETY GLASSES (ON-SITE LOCATIONS TO PROVIDE REQUIRED PERSONAL PROTECTIVE EQUIPMENT)

FOR VIRTUAL CLASSES:

CONTENT MATERIAL WILL BE PROVIDED IN DIGITAL FORMAT

NOTE: All items indicated with an asterisk (*) must be supplied by the client on On-Site courses