

TABLE OF CONTENTS

About This Textbook	x	4.4	High-Voltage Transmission Lines.....	34	
Additional Products to Help You Learn	xiii	4.5	Primary Distribution Voltage	34	
How to Use the <i>National Electrical Code</i>	1	4.6	Primary Distribution Wires	34	
		4.7	Secondary Distribution Voltage	34	
		4.8	Service Drop and Service Lateral.....	35	
			Unit 4—Review Questions	36	
SECTION I—ELECTRICAL THEORY	7				
Unit 1—Atomic Structure	9		Unit 6—Dangers of Electricity	39	
1.1 Introduction	9	6.1	Introduction	39	
1.2 Atomic Theory	9	6.2	<i>National Electrical Code (NEC)</i>	39	
1.3 Electrostatic Field.....	10	6.3	Electrical Fire	39	
1.4 Atomic Charge of an Atom	11	6.4	Electric Shock.....	40	
1.5 Electrostatic Charge and Discharge.....	12	6.5	Electric Arc Flash and Arc Blast	41	
1.6 Lightning	13	6.6	Arc Flash Incident Energy	42	
1.7 Lightning Protection System.....	14	6.7	Electrically Safe Work Condition	43	
Unit 1—Review Questions	15	6.8	Personal Protective Equipment (PPE).....	43	
			Unit 6—Review Questions	45	
Unit 2—Electron Theory and Chemical Bonding	19		Unit 25—Overcurrent Protection	49	
2.1 Introduction	19	25.1	Introduction	49	
2.2 Electron Orbitals.....	19	25.2	Overcurrent Protection	49	
2.3 Valence Electrons.....	19	25.3	Fuses	50	
2.4 Freeing Valence Electron(s) from an Atom.....	20	25.4	Circuit Breakers.....	52	
2.5 Conductance	20	25.5	Overcurrent Protective Devices, Time-Current Curves	53	
2.6 Insulators	22		Unit 25—Review Questions	56	
Unit 2—Review Questions	23				
Unit 3—Electrical Circuits and Power Sources	25				
3.1 Introduction	25		SECTION II—NEC RULES FOR BONDING AND GROUNDING	59	
3.2 The Electrical Circuit.....	25				
3.3 Electric Current Flow (Electricity).....	25		Article 90—Introduction to the <i>National Electrical Code</i>	61	
3.4 Electrical Power Sources	26		90.1	Scope	61
Unit 3—Review Questions	30		90.2	Use and Application of the <i>NEC</i>	61
			90.3	Code Arrangement.....	65
Unit 4—The Electrical System	33		90.4	<i>NEC</i> Enforcement	66
4.1 Introduction	33		90.5	Mandatory Requirements and Explanatory Material	67
4.2 Source of Electrical Generation.....	33		90.7	Examination of Equipment for Safety	68
4.3 Step-Up Transmission Voltage	33		Article 90—Review Questions	69	

CHAPTER 1—GENERAL RULES	73	Part III. Grounding Electrode System and Grounding Electrode Conductor	154
Article 100—Definitions	75	250.50 Grounding Electrode System.....	154
Article 110—General Requirements for Electrical Installations	101	250.52 Grounding Electrode Types.....	155
Part I. General Requirements	101	250.53 Grounding Electrode Installation.....	159
110.1 Scope	101	Soil Resistivity	162
110.2 Approval of Conductors and Equipment.....	102	250.54 Auxiliary Grounding Electrodes	162
110.3 Use of Equipment.....	102	250.60 Lightning Protection Electrode.....	164
110.5 Conductor Material	104	250.62 Grounding Electrode Conductor	164
110.6 Conductor Sizes	104	250.64 Grounding Electrode Conductor Installation.....	164
110.7 Wiring Integrity	104	250.66 Sizing Grounding Electrode Conductors.....	169
110.8 Suitable Wiring Methods	104	250.68 Grounding Electrode Conductor Connection to Grounding Electrodes	170
110.11 Deteriorating Agents.....	105	250.70 Grounding Electrode Conductor Termination Fittings.....	172
110.12 Mechanical Execution of Work	106	Part IV. Enclosure and Raceway	173
110.14 Conductor Termination and Splicing.....	107	250.80 Service Raceways and Enclosures	173
Chapter 1—Review Questions	113	250.86 Other than Service Raceways and Enclosures	174
CHAPTER 2—WIRING AND PROTECTION	123	Part V. Bonding	174
Article 215—Feeders	125	250.92 Bonding Metal Service Raceways and Enclosures	174
215.1 Scope	125	250.94 Bonding for Communications Systems	177
215.6 Feeder Equipment Grounding Conductor.....	126	250.97 Bonding Metal Raceways and Metal Cables Containing 277V and 480V Circuits	178
Article 250—Grounding and Bonding	127	250.98 Bonding Loosely Jointed Metal Raceways.....	179
Part I. General	128	250.100 Bonding in Hazardous (Classified) Locations	179
250.1 Scope	128	250.102 Bonding Jumper Sizing.....	179
250.4 Performance Requirements for Grounding and Bonding	129	250.104 Bonding of Piping Systems and Exposed Structural Metal	183
Earth Shells	133	250.106 Lightning Protection Systems.....	186
250.6 Objectionable Current.....	134	Part VI. Equipment Grounding Conductors	186
Objectionable Current	134	250.109 Metal Enclosures, Effective Ground-Fault Current Path.....	186
Dangers of Objectionable Current	136	250.114 Equipment Connected by Cord and Plug	186
250.8 Connection of Grounding and Bonding Conductors.....	137	250.118 Types of Equipment Grounding Conductors.....	187
250.10 Protection of Ground Clamps and Fittings	137	250.119 Identification of Wire-Type Equipment Grounding Conductors	191
250.12 Clean Surfaces	137	250.120 Equipment Grounding Conductor Installation.....	193
Part II. System Grounding and Bonding	138	250.122 Sizing Wire-Type Equipment Grounding Conductors.....	193
250.20 Systems Required to be Grounded	138	Part VII. Equipment Grounding Conductor Connections	196
250.21 Ungrounded Systems	138	250.134 Equipment Connected by Permanent Wiring Methods	196
250.24 Service Grounding	139	250.138 Cord-and-Plug-Connected	197
250.28 Main Bonding Jumper and System Bonding Jumper.....	143	250.140 Frames of Ranges, Ovens, and Clothes Dryers.....	197
250.30 Transformer Separately Derived Systems.....	145	250.146 Connecting Receptacle Grounding Terminal to an Equipment Grounding Conductor	197
Generator Separately Derived Systems	151	250.148 Continuity and Attachment of Equipment Grounding Conductors in Boxes	200
250.32 Buildings Supplied by a Feeder	152	Chapter 2—Review Questions	202
250.36 Impedance Grounded Systems—480V to 1000V.....	153		

CHAPTER 3—WIRING METHODS AND MATERIALS	221
Article 300—General Requirements for Wiring Methods and Materials.....	225
Part I. General Requirements	225
300.1 Scope	225
300.3 Conductors	226
300.6 Protection Against Corrosion.....	227
300.10 Electrical Continuity.....	228
300.12 Mechanical Continuity.....	229
300.20 Reducing Inductive Heating.....	230
Article 314—Boxes, Conduit Bodies, and Handhole Enclosures.....	233
Part I. General	233
314.1 Scope	233
314.3 Nonmetallic Boxes	234
314.4 Metal Boxes	234
314.30 Handhole Enclosures.....	234
Article 320—Armored Cable (Type AC).....	237
320.1 Scope	237
320.108 Equipment Grounding Conductor	238
Article 330—Metal-Clad Cable (Type MC).....	239
330.1 Scope	240
330.108 Equipment Grounding Conductor	240
Article 334—Nonmetallic-Sheathed Cable (Type NM).....	243
334.1 Scope	243
334.108 Equipment Grounding Conductor	243
Article 340—Underground Feeder and Branch-Circuit Cable (Type UF).....	245
340.1 Scope	245
340.108 Equipment Grounding Conductor	246
Article 342—Intermediate Metal Conduit (IMC).....	247
342.1 Scope	247
342.60 Equipment Grounding Conductor	247
Article 344—Rigid Metal Conduit (RMC).....	249
344.1 Scope	249
344.60 Equipment Grounding Conductor	250
Article 348—Flexible Metal Conduit (FMC)	251
348.1 Scope	251
348.60 Equipment Grounding and Bonding Conductors	252
Article 350—Liquidtight Flexible Metal Conduit (LFMC)	253
350.1 Scope	253
350.60 Equipment Grounding and Bonding Conductors	254
Article 352—Rigid Polyvinyl Chloride Conduit (PVC).....	255
352.1 Scope	255
352.60 Equipment Grounding Conductor	256
Article 356—Liquidtight Flexible Nonmetallic Conduit (LFNC)	257
356.1 Scope	257
356.60 Equipment Grounding Conductor	258
Article 358—Electrical Metallic Tubing (EMT).....	259
358.1 Scope	259
358.60 Equipment Grounding Conductor	260
Article 362—Electrical Nonmetallic Tubing (ENT).....	261
362.1 Scope	261
362.60 Equipment Grounding Conductor	262
Article 376—Metal Wireways.....	263
376.1 Scope	263
376.60 Equipment Grounding Conductor	264
Article 386—Surface Metal Raceways.....	265
386.1 Scope	265
386.60 Equipment Grounding Conductor	266
Article 392—Cable Trays.....	267
392.1 Scope	267
392.60 Equipment Grounding Conductor	268
Chapter 3—Review Questions	270

CHAPTER 4—EQUIPMENT FOR GENERAL USE	275	Article 517—Health Care Facilities	307
Article 404—Switches	277	517.1 Scope	307
404.1 Scope	277	517.13 Equipment Grounding Conductor for Receptacles and Fixed Electrical Equipment in Patient Care Spaces.....	308
404.9 General-Use Snap Switches, Dimmers, and Control Switches	278	517.16 Isolated Ground Receptacles.....	310
404.12 Bonding of Enclosures.....	279		
Article 406—Receptacles, Attachment Plugs, and Flanged Inlets	281	Article 547—Agricultural Buildings	313
406.1 Scope	282	547.1 Scope	313
406.3 Receptacle Rating and Type	282	547.44 Equipotential Planes	314
406.4 General Installation Requirements.....	282		
406.11 Connecting Receptacle Grounding Terminal to Equipment Grounding Conductor	284		
Article 408—Switchboards and Panelboards	285	Article 555—Marinas, Boatyards, and Docking Facilities	317
408.1 Scope	285	555.1 Scope	317
408.40 Equipment Grounding Conductor.....	285	555.37 Equipment Grounding Conductor.....	317
Article 410—Luminaires	287	Chapter 5—Review Questions	319
410.1 Scope	287		
410.30 Supports	288		
410.44 Connection to the Equipment Grounding Conductor	289		
410.182 Equipment Grounding Conductor.....	290		
Article 440—Air-Conditioning Equipment	291	CHAPTER 6—SPECIAL EQUIPMENT	323
440.1 Scope	291	Article 600—Electric Signs	325
440.9 Equipment Grounding Conductor.....	292	600.1 Scope	325
		600.7 Grounding and Bonding.....	326
Article 450—Transformers	293	Article 645—Information Technology Equipment (ITE)	329
450.1 Scope	293	645.1 Scope	329
450.10 Grounding and Bonding.....	294	645.15 Equipment Grounding and Bonding.....	329
Chapter 4—Review Questions	295		
CHAPTER 5—SPECIAL OCCUPANCIES	299	Article 680—Swimming Pools, Spas, Hot Tubs, Fountains, and Similar Installations	331
Article 501—Class I Hazardous (Classified) Locations	301	Part I. General Requirements for Pools, Spas, Hot Tubs, and Fountains	332
501.1 Scope	301	680.1 Scope	332
501.30 Grounding and Bonding.....	301	680.7 Grounding and Bonding.....	332
Article 502—Class II Hazardous (Classified) Locations	305	Part II. Permanently Installed Pools	333
502.1 Scope	305	680.23 Underwater Pool Luminaires	333
502.30 Grounding and Bonding.....	306	680.24 Junction Box, Transformer, or GFCI Enclosure	336
		680.26 Equipotential Bonding	337
		Part IV. Hot Tubs	342
		680.40 General.....	342
		680.42 Outdoor Installations.....	342
		Part V. Fountains	343
		680.50 General.....	343
		680.54 Connection to an Equipment Grounding Conductor.....	343
		680.55 Methods of Equipment Grounding	344
		680.56 Cord-and-Plug-Connected Equipment.....	344

Part VII. Hydromassage Bathtubs.....	344
680.70 General	344
680.74 Equipotential Bonding	344
Article 690—Solar Photovoltaic (PV) Systems.....	347
Part I. General	347
690.1 Scope	347
690.43 Equipment Grounding Conductor.....	348
690.45 Size of Equipment Grounding Conductors	349
690.47 Grounding Electrode System	349
Chapter 6—Review Questions.....	351
CHAPTER 8—COMMUNICATIONS SYSTEMS	357
Article 810—Antenna Systems	359
Part I. General	359
810.1 Scope	359
Part II. Receiving Equipment—Antenna Systems.....	360
810.15 Metal Antenna Supports—Bonding	360
810.20 Antenna Discharge Unit.....	360
810.21 Bonding Conductors and Grounding Electrode Conductors ..	360
Chapter 8—Review Questions.....	363
NEC FINAL EXAM A—STRAIGHT ORDER.....	365
NEC FINAL EXAM B—RANDOM ORDER	377
INDEX	389
About the Author	395
About the Illustrator	396
About the Mike Holt Team	397