ARTICLE
110 Requirements for Electrical Installations

INTRODUCTION TO ARTICLE 110—REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

Article 110 sets the stage for how you'll implement the rest of the *NEC*. This article contains a few of the most important and yet neglected parts of the *Code*. For example:

- How should conductors be terminated?
- What kinds of warnings, markings, and identification does a given installation require?
- What's the right working clearance for a given installation?
- What do the temperature limitations at terminals mean?
- What are the *NEC* requirements for dealing with flash protection?

It's critical that you master Article 110. As you read this article, you're building your foundation for correctly applying the *NEC*. In fact, this article itself is a foundation for much of the *Code*. The purpose for the *National Electrical Code* is to provide a safe installation, but Article 110 is perhaps focused a little more on providing an installation that is safe for the installer and maintenance electrician, so time spent in this article is time well spent.

Essential Rule 7 **110.2**

PART I. GENERAL REQUIREMENTS

110.2 Approval of Conductors and Equipment. The authority having jurisdiction must approve all electrical conductors and equipment. Figure 110–1

Author's Comment: For a better understanding of product approval, review 90.4, 90.7, 110.3 and the definitions for "Approved," "Identified," "Labeled," and "Listed" in Article 100.

Figure 110–1

Essential Rule 8 **110.3**

110.3 Examination, Identification, Installation, and Use of Equipment.

(A) Guidelines for Approval. The authority having jurisdiction must approve equipment. In doing so, consideration must be given to the following:

(1) Suitability for installation and use in accordance with the *NEC*

Note: Suitability of equipment use may be identified by a description marked on or provided with a product to identify the suitability of the product for a specific purpose, environment, or application. Special conditions of use or other limitations may be marked on the equipment, in the product instructions, or appropriate listing and labeling information. Suitability of equipment may be evidenced by listing or labeling.

(2) Mechanical strength and durability

(3) Wire-bending and connection space

(4) Electrical insulation

(5) Heating effects under all conditions of use

(6) Arcing effects

(7) Classification by type, size, voltage, current capacity, and specific use

(8) Other factors contributing to the practical safeguarding of persons using or in contact with the equipment

(B) Installation and Use. Equipment must be installed and used in accordance with any instructions included in the listing or labeling requirements. **Figure 110–2**

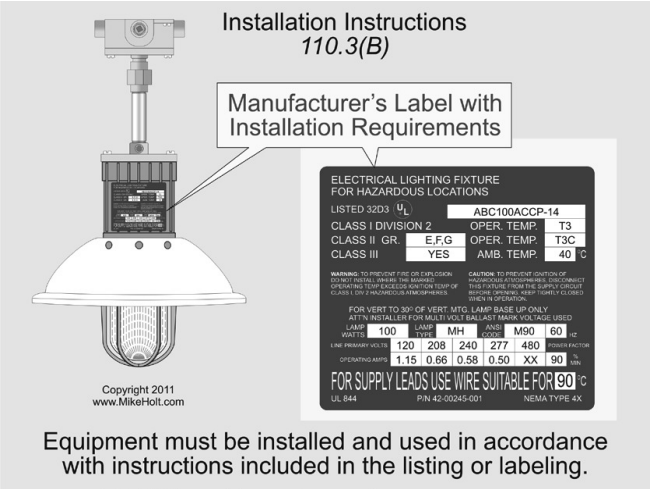

Figure 110–2

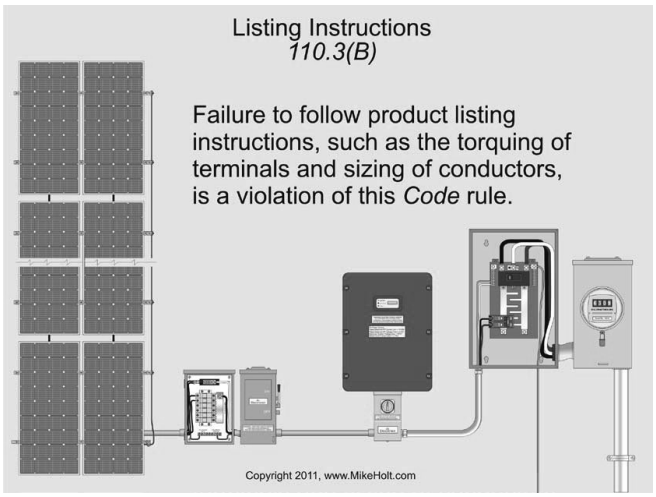

Figure 110–3

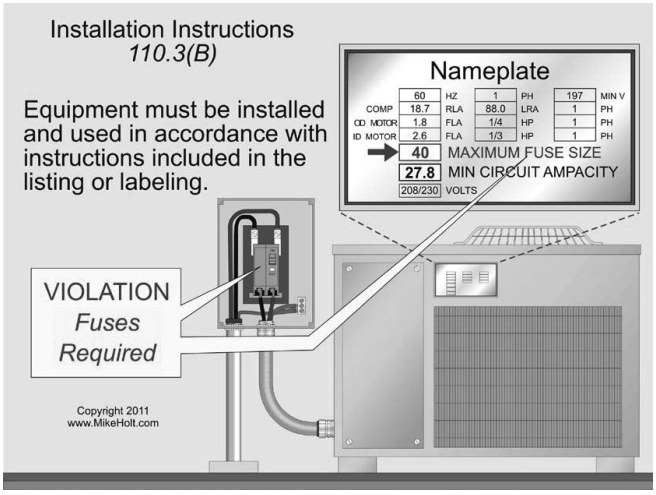

Figure 110–4

Author's Comments:

- See the definitions of "Labeling" and "Listing" in Article 100.
- Failure to follow product listing instructions, such as the torquing of terminals and the sizing of conductors, is a violation of this *Code* rule. **Figure 110–3**
- When an air conditioner nameplate specifies "Maximum Fuse Size," one-time or dual-element fuses must be used to protect the equipment. **Figure 110–4**

Essential Rule 9 110.14

110.14 Conductor Termination and Splicing. Conductor terminal and splicing devices must be identified for the conductor material and they must be properly installed and used. **Figure 110–5**

Connectors and terminals for conductors more finely stranded than Class B and Class C, as shown in Table 10 of Chapter 9, must be identified for the conductor class. **Figure 110–6**

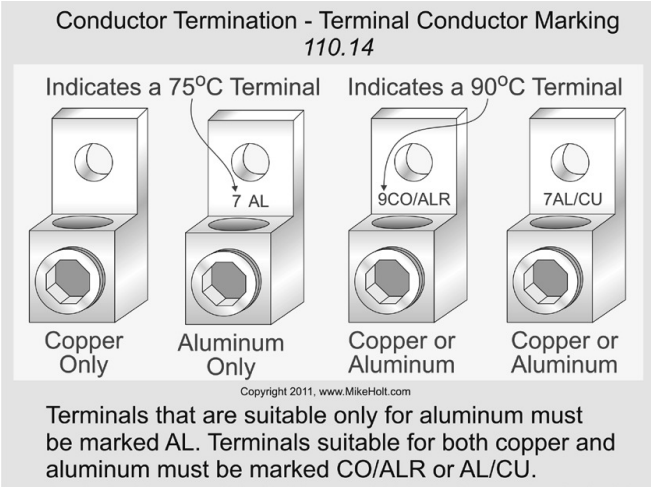

Figure 110–5

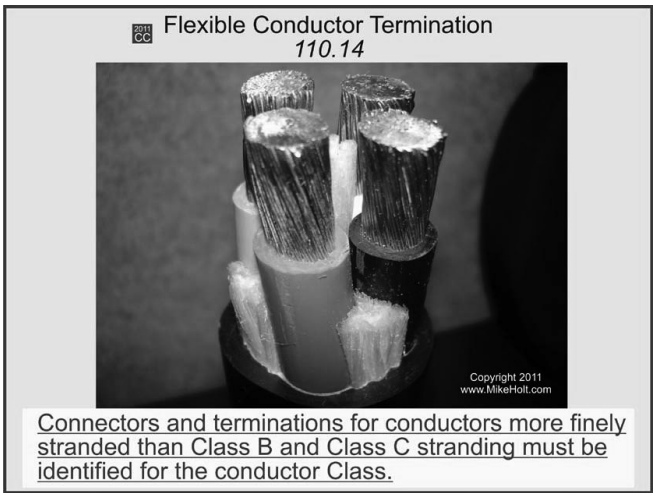

Figure 110–6

Author's Comments:

- According to UL Standard 486 A-B, a terminal/lug/connector must be listed and marked for use with conductors stranded in other than Class B. With no marking or factory literature/instructions to the contrary, terminals may only be used with Class B stranded conductors.
- Class D stranding has 37 strands of wire per conductor in sizes 18-2 AWG, 61 strands in sizes 1-4/0 AWG, and 91 strands in sizes 250-500 kcmil.

Switches and receptacles marked CO/ALR are designed to ensure a good connection through the use of the larger contact area and compatible materials. The terminal screws are plated with the element called "Indium." Indium is an extremely soft metal that forms a gas-sealed connection with the aluminum conductor.

Author's Comments:

- See the definition of "Identified" in Article 100.
- Conductor terminations must comply with the manufacturer's instructions as required by 110.3(B). For example, if the instructions for the device state "Suitable for 18-12 AWG Stranded," then only stranded conductors can be used with the terminating device. If the instructions state "Suitable for 18-12 AWG Solid," then only solid conductors are permitted, and if the instructions state "Suitable for 18-12 AWG," then either solid or stranded conductors can be used with the terminating device.

Copper and Aluminum Mixed. Copper and aluminum conductors must not make contact with each other in a device unless the device is listed and identified for this purpose.

Author's Comment: Few terminations are listed for the mixing of aluminum and copper conductors, but if they are, that will be marked on the product package or terminal device. The reason copper and aluminum shouldn't be in contact with each other is because corrosion develops between the two different metals due to galvanic action, resulting in increased contact resistance at the splicing device. This increased resistance can cause the splice to overheat and cause a fire.

Note: Many terminations and equipment are marked with a tightening torque, see Table I.1 in Informative Annex I.

Author's Comment: Conductors must terminate in devices that have been properly tightened in accordance with the manufacturer's torque specifications included with equipment instructions. Failure to torque terminals can result in excessive heating of terminals or splicing devices due to a loose connection. A loose connection can also lead to arcing which increases the heating effect and also may lead to a short circuit or ground fault. Any of these can result in a fire or other failure, including an arc-flash event. In addition, this is a violation of 110.3(B), which requires all equipment to be installed in accordance with listing or labeling instructions. **Figure 110–7**

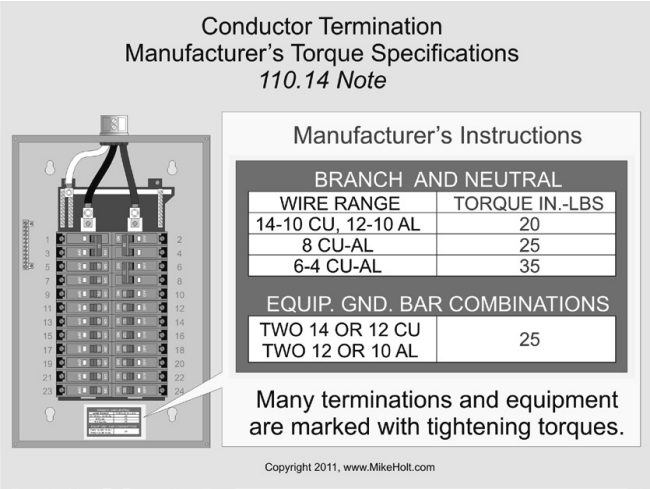

Figure 110–7

Question: *What do you do if the torque value isn't provided with the device?*

Answer: *Call the manufacturer, visit the manufacturer's Website, or have the supplier make a copy of the installation instructions.*

Author's Comment: Terminating conductors without a torque tool can result in an improper and unsafe installation. If a torque screwdriver isn't used, there's a good chance the conductors aren't properly terminated.

(A) Terminations. Conductor terminals must ensure a good connection without damaging the conductors and must be made by pressure connectors (including set screw type) or splices to flexible leads.

Author's Comment: See the definition of "Connector, Pressure" in Article 100.

Question: *What if the conductor is larger than the terminal device?*

Answer: *This condition needs to be anticipated in advance, and the equipment should be ordered with terminals that will accommodate the larger conductor. However, if you're in the field, you should:*

- *Contact the manufacturer and have them express deliver you the proper terminals, bolts, washers, and nuts, or*
- *Order a terminal device that crimps on the end of the larger conductor and reduces the termination size.*

Terminals for more than one conductor and terminals used for aluminum conductors must be identified for this purpose, either within the equipment instructions or on the terminal itself. **Figure 110–8**

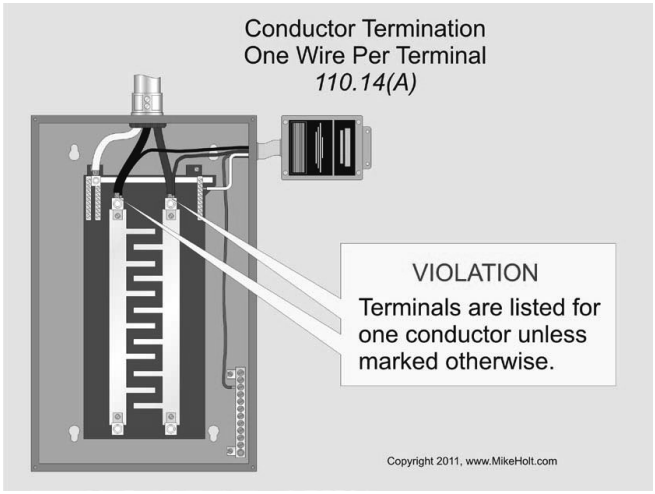

Figure 110–8

Author's Comments:

- Split-bolt connectors are commonly listed for only two conductors, although some are listed for three conductors. However, it's a common industry practice to terminate as many conductors as possible within a split-bolt connector, even though this violates the *NEC*. **Figure 110–9**
- Many devices are listed for more than one conductor per terminal. For example, some circuit breakers rated 30A or less can have two conductors under each lug. Grounding and bonding terminals are also often listed for more than one conductor under the terminal.
- Each neutral conductor within a panelboard must terminate to an individual terminal [408.41].

(B) Conductor Splices. Conductors must be spliced by a splicing device identified for the purpose or by exothermic welding.

Author's Comment: Conductors aren't required to be twisted together prior to the installation of a twist-on wire connector, unless specifically required in the installation instructions. **Figure 110–10**