

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's safe for the installer and maintenance electrician, so time spent in this article is time well spent.

Part I. General Requirements

110.1 Scope

Article 110 covers the general requirements for the examination and approval, installation and use, access to and spaces about electrical equipment; as well as general requirements for enclosures intended for personnel entry (manholes, vaults, and tunnels).

Note: See Annex J for information regarding ADA accessibility design.

Author's Comment:

- Requirements for people with disabilities include things like mounting heights for switches and receptacles, and requirements for the distance that objects such as wall sconces protrude from a wall.

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

Changes to this section of the *Code* include addressing reconditioned, refurbished, or remanufactured equipment and providing rules for who may list electrical equipment.

Analysis



NEW

Remanufactured Equipment. In a perfect world all electrical equipment would be shiny and new; but that isn't reality. Sometimes older electrical equipment must continue to be used for many reasons, the most common is availability and cost. It would be nice if we could change all of the existing equipment in the world into new,



but since we can't we have to make do. This often includes installing electrical equipment that isn't new, but is reconditioned, refurbished, or remanufactured instead. This is commonly done with circuit breakers for obscure panels that haven't been manufactured in decades. A new Informational Note points out that the inspector shouldn't reject equipment based solely on the fact that it's remanufactured.



Listing. A new subsection (C), covering listing, was added. Although the definition of "listed" in Article 100 states that a testing laboratory that tests and lists products must be acceptable to the AHJ, it does little else in terms of regulating the listing agency. This makes sense, because definitions aren't supposed to contain rules.

So, who does the testing and listing, and what do they use as their basis of acceptance? Can I open my own company, test a product in my backyard shop by plugging it in, put a sticker on it, and call it listed? With the revisions in the 2017 *NEC*, you can't. Testing laboratories must be recognized as being qualified and one source of finding out which ones are is OSHA, which lists Nationally Recognized Testing Laboratories (NRTLs).

110.3 Examination, Identification, Installation, Use, and Product Listing (Certification) 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 1: Equipment may be new, reconditioned, refurbished, or remanufactured.

Note 2: 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 110-1](#)



Figure 110-1

Author's Comment:

- 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 110-2](#)

(C) Product Listing (Certification). Product certification (testing, evaluation, and listing) must be performed by a recognized qualified testing laboratory in accordance with standards that achieve effective safety to comply with the *NEC*.

Note: OSHA recognizes qualified electrical testing laboratories that provide product certification that meets OSHA electrical standards.

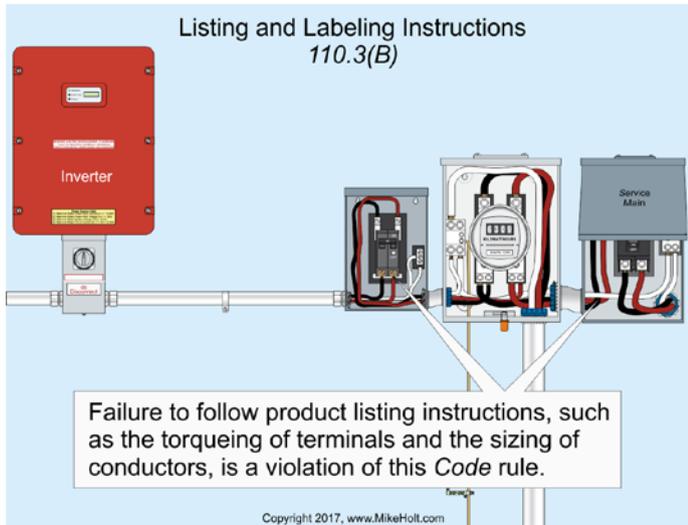


Figure 110-2

110.5 Conductors

A change to this rule clarifies that conductors are to be copper or aluminum unless otherwise restricted by the *NEC*.

Analysis



CLARIFIED

This section used to stipulate that, where conductor material wasn't specified in the *Code* rule, copper conductors were to be used. This made for some strange interpretations of the *NEC*, none of which made sense or could be justified as necessary.

Aluminum conductors have the same negative stigma (for some) that they've had for decades, despite being made from different and far superior alloys than their predecessors. With the change to this section, there's no argument about the allowed conductor types. Aluminum can be used unless there's a specific requirement by the equipment listing or *Code* rule, such as 517.13(B)(1).

110.5 Conductors

Conductors are to be copper [or aluminum](#) unless otherwise provided in this *Code*; and when the conductor material isn't specified in a rule, [the sizes](#) given in the *Code* are based on a copper conductor.

110.9 Interrupting Overcurrent Protection Rating

A change to this very important rule creates enforceable language.

Analysis



CLARIFIED

Section 110.9 mandates that circuit breakers and fuses be capable of interrupting the circuit in the event of a ground fault without experiencing extensive damage. What's extensive damage?

When overcurrent protection devices are subjected to fault currents above their rating, they can literally explode, taking down everything in their path in the process. Because of this, it's critical to ensure that overcurrent protection devices be rated to handle the fault current on their line terminals.

Previous editions of the *NEC* stated that overcurrent protection devices must be "sufficient" for the available fault current. The word "sufficient" isn't a word that's used very often in the *Code*, because it lends itself to interpretation. What's "sufficient?" With the *NEC* now stating that the device rating must be "at least equal to" the available fault current, the opportunity for debate is closed.

110.9 Interrupting Overcurrent Protection Rating

Overcurrent protection devices such as circuit breakers and fuses are intended to interrupt the circuit, and they must have an interrupting rating at the nominal circuit voltage [at least equal to](#) the current available at the line terminals of the equipment. [Figure 110-3](#)

Author's Comment:

- See the definition of "Interrupting Rating" in Article 100.
- Ampere Interrupting Rating (AIR) is also described as "Ampere Interrupting Capacity" (AIC) by many in the industry.
- Unless marked otherwise, the ampere interrupting rating for circuit breakers is 5,000A [240.83(C)], and for fuses it's 10,000A [240.60(C)(3)]. [Figure 110-4](#)

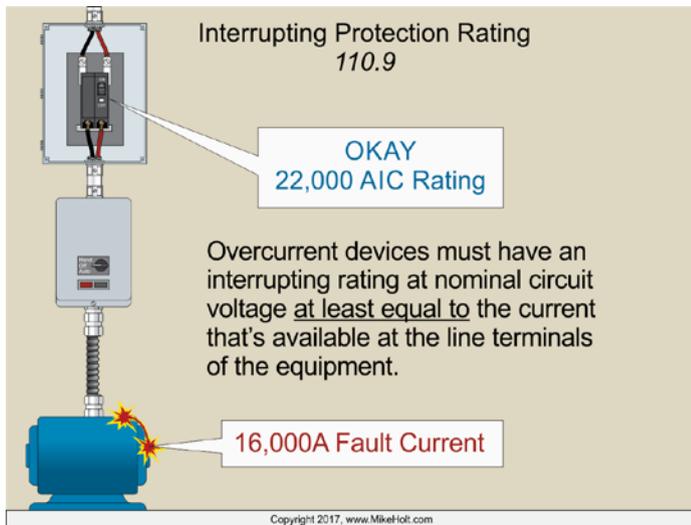


Figure 110-3

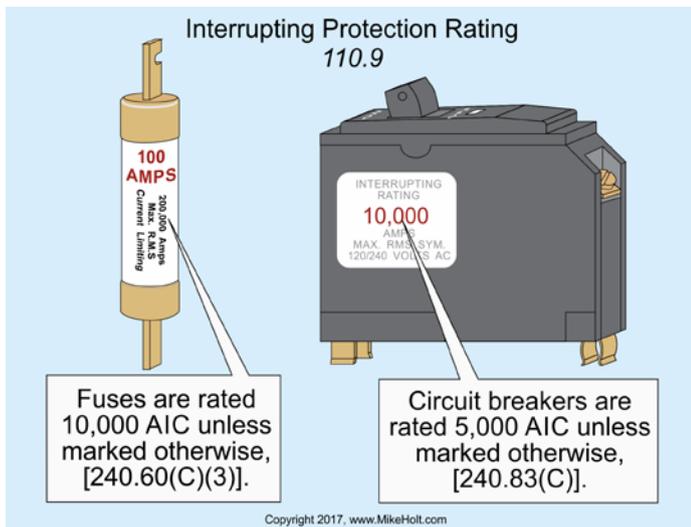


Figure 110-4

Available Short-Circuit Current

Available short-circuit current is the current, in amperes, available at a given point in the electrical system. This available short-circuit current is first determined at the secondary terminals of the electric utility transformer, as given by the electric utility engineer. Thereafter, the available short-circuit current is calculated at the terminals of service equipment, then at branch-circuit panelboards and other equipment. The available short-circuit current is different at each point of the electrical system. It's highest at the electric utility transformer and lowest at the branch-circuit load.

The available short-circuit current depends on the impedance of the circuit. The greater the circuit impedance (utility transformer and the additive impedances of the circuit conductors), the lower the available short-circuit current. Figure 110-5

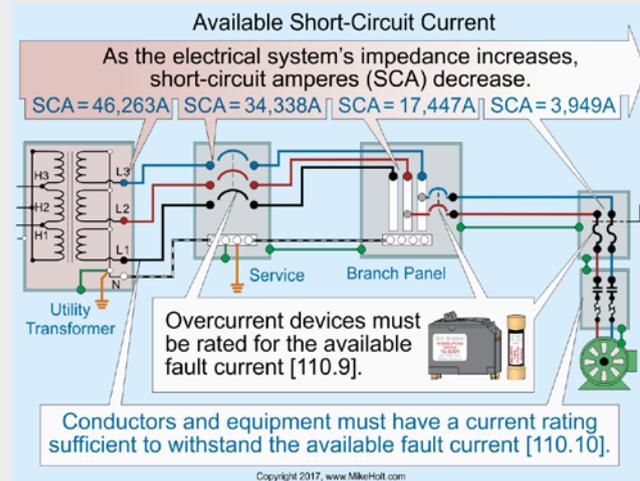


Figure 110-5

The factors that affect the available short-circuit current at the electric utility transformer include the system voltage, the transformer kVA rating, and the circuit impedance (expressed in a percentage on the equipment nameplate). Properties that have an impact on the impedance of the circuit include the conductor material (copper versus aluminum), conductor size, conductor length, and motor-operated equipment supplied by the circuit.



DANGER: Extremely high values of current flow (caused by short circuits or ground faults) produce tremendously destructive thermal and magnetic forces. An overcurrent protection device not rated to interrupt the current at the available fault values at its listed voltage rating can explode while attempting to open the circuit overcurrent protection device from a short circuit or ground fault, which can cause serious injury or death, as well as property damage. Figure 110-6

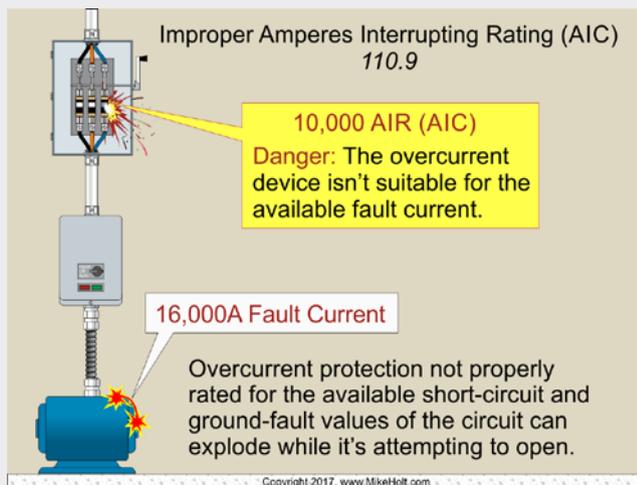


Figure 110-6

110.11 Deteriorating Agents

A new Informational Note intended to make *Code* users aware that there are minimum flood provisions contained in other building codes as they relate to electrical installations was added.

Analysis



NEW

Typically, installing electrical equipment below the flood hazard level isn't allowed by the building code unless the equipment is suitable for the location. In some areas local rules require GFCI protection for equipment in flood zones, while in other areas, electrical equipment isn't permitted in the flood hazard zone at all. This new Informational Note should help designers and installers to be mindful of the building code requirements.

110.11 Deteriorating Agents

Electrical equipment and conductors must be suitable for the environment and conditions of use. Consideration must also be given to the presence of corrosive gases, fumes, vapors, liquids, or other substances that can have a deteriorating effect on the conductors or equipment. Figure 110-7

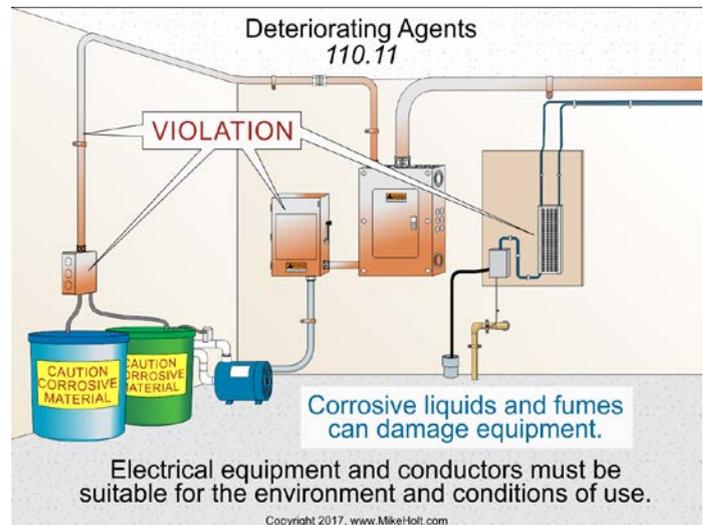


Figure 110-7

Author's Comment:

- Conductors aren't permitted to be exposed to ultraviolet rays from the sun unless identified for the purpose [310.10(D)].

Note 1: Raceways, cable trays, cablebus, cable armor, boxes, cable sheathing, cabinets, elbows, couplings, fittings, supports, and support hardware must be of materials that are suitable for the environment in which they're to be installed, in accordance with 300.6.

Note 2: Some cleaning and lubricating compounds contain chemicals that can cause deterioration of the plastic used for insulating and structural applications in equipment.

Equipment not identified for outdoor use and equipment identified only for indoor use must be protected against damage from the weather during construction.

Note 3: See Table 110.28 for NEMA enclosure-type designations.

Note 4: See the [International Building Code \(IBC\)](#) and the [International Residential Code \(IRC\)](#) for minimum flood provisions.

110.14 Conductor Termination and Splicing

A properly calibrated tool must be used when torquing terminal connections.

Analysis



NEW

When electrical fires or failures occur, they usually do so at terminations, not in the middle of a cable or conductor. With that said, the rules in 110.14 are some of the most important in the entire *Code*.

Studies have found that approximately 75 to 80 percent of conductor terminations aren't installed correctly unless a torque measuring device, such as a torque wrench or screwdriver, is used. Approximately 60 percent of conductor terminations aren't tight enough and 20 percent are too tight, leaving about only 20 percent meeting the manufacturer's torquing requirements.

This new rule requires the installer to use a properly calibrated tool for conductor terminations when a tightening torque is specified by the manufacturer for the terminal.

Enforcement of this new rule will prove challenging. Does the electrical inspector need to be on site when the terminations are made so he or she can verify the tool being used? How will he or she know the tool is calibrated corrected? Has the tool been dropped since being calibrated and is now therefore inaccurate? Should the inspectors carry their own tools?

As with any new *Code* rule, this one might create growing pains, but we can all certainly agree on one thing; this rule is intended to increase safety by ensuring proper terminations. Let's not lose sight of the big picture—electrical safety.

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 110-8



Figure 110-8

Author's Comment:

- Switches and receptacles marked CO/ALR are designed to ensure a good connection through the use of a 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.

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 use of finely stranded conductors. Figure 110-9



Figure 110-9

Author's Comment:

- According to UL Standard 486 A-B, a terminal/lug/connector must be listed and marked for use with other than Class B stranded conductors. With no marking or factory literature/instructions to the contrary, terminals may only be used with Class B stranded conductors.
- 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.

(A) Terminations. Conductor terminals must ensure a good connection without damaging the conductors.

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 110-10](#)

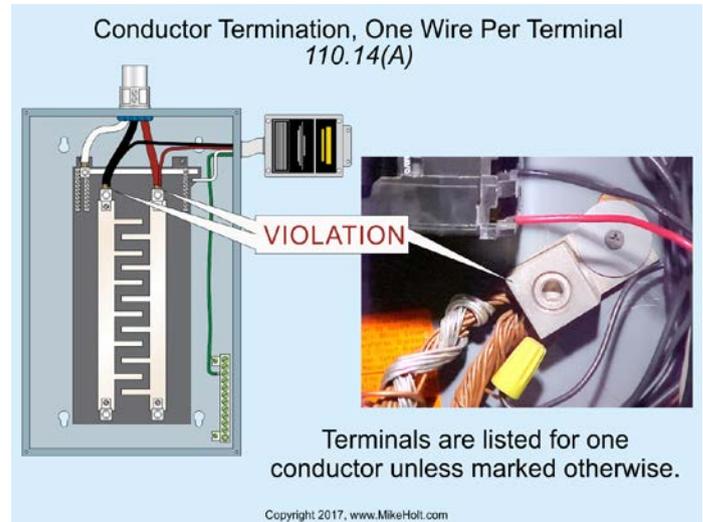


Figure 110-10

Author's Comment:

- 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 110-11](#)

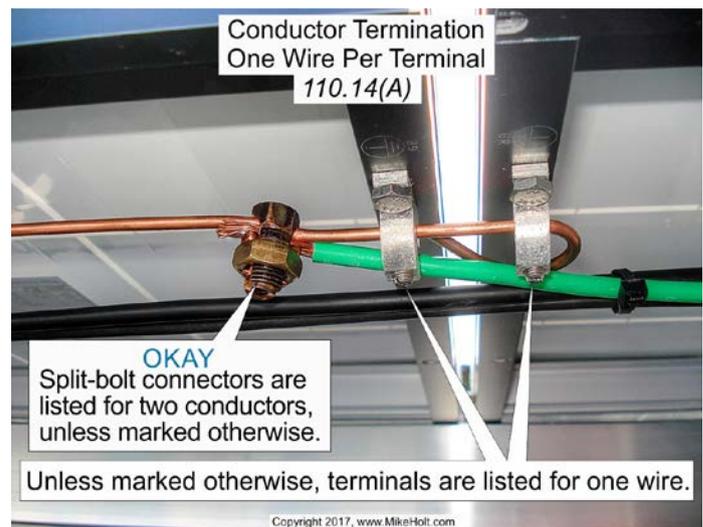


Figure 110-11

(B) Conductor Splices. Conductors must be spliced by a splicing device identified for the purpose or by exothermic welding. [Figure 110-12](#)

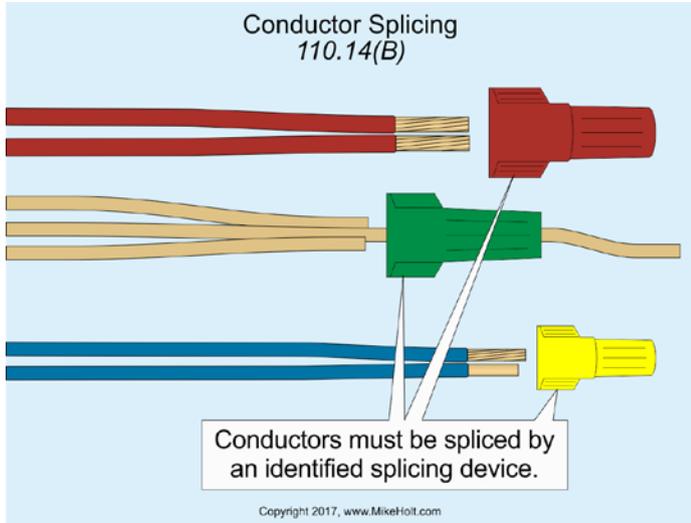


Figure 110-12

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 110-13](#)



Figure 110-13

Unused circuit conductors aren't required to be removed. However, to prevent an electrical hazard, the free ends of the conductors must be insulated to prevent the exposed end of the conductor from touching energized parts. This requirement can be met by the use of an insulated twist-on or push-on wire connector. [Figure 110-14](#)

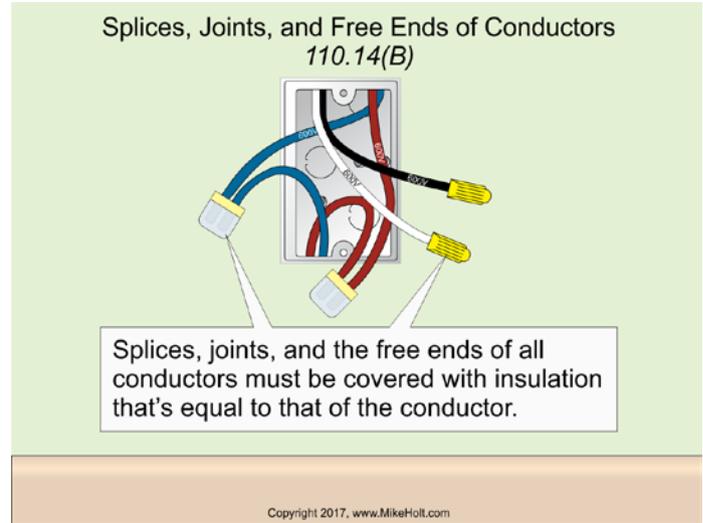


Figure 110-14

Author's Comment:

- See the definition of "Energized" in Article 100.

Underground Splices:

Single Conductors. Single direct burial conductors of types UF or USE can be spliced underground without a junction box, but the conductors must be spliced with a device listed for direct burial [300.5(E) and 300.15(G)]. [Figure 110-15](#)

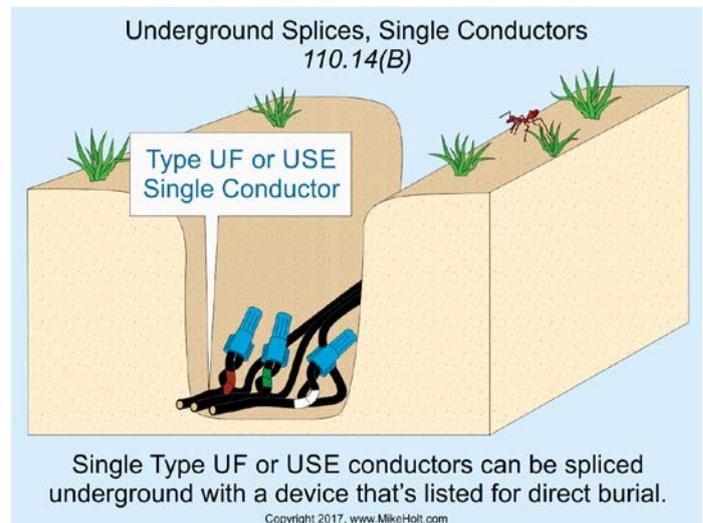


Figure 110-15

Multiconductor Cable. Multiconductor UF or USE cable can have the individual conductors spliced underground without a junction box as long as a listed splice kit that encapsulates the conductors as well as the cable jacket is used.

(C) Temperature Limitations (Conductor Size). Conductors are to be sized using their ampacity from the insulation temperature rating column of Table 310.15(B)(16) that corresponds to the lowest temperature rating of any terminal, device, or conductor of the circuit.

Conductors with insulation temperature ratings higher than the termination's temperature rating can be used for ampacity adjustment, correction, or both. [Figure 110–16](#)

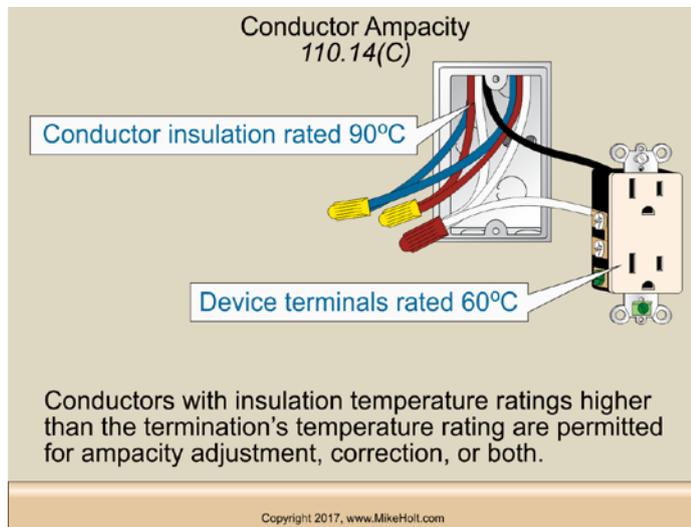


Figure 110–16

(1) Equipment Temperature Rating Provisions. Unless the equipment is listed and marked otherwise, conductor sizing for equipment terminations must be based on Table 310.15(B)(16) in accordance with (a) or (b):

(a) Equipment Rated 100A or Less.

- (1) Conductors must be sized using the 60°C temperature column of Table 310.15(B)(16). [Figure 110–17](#)
- (3) Conductors terminating on terminals rated 75°C are to be sized in accordance with the ampacities listed in the 75°C temperature column of Table 310.15(B)(16). [Figure 110–18](#)

**Conductor Sizing, Equipment Rated 100A or Less
110.14(C)(1)(a)(1)**

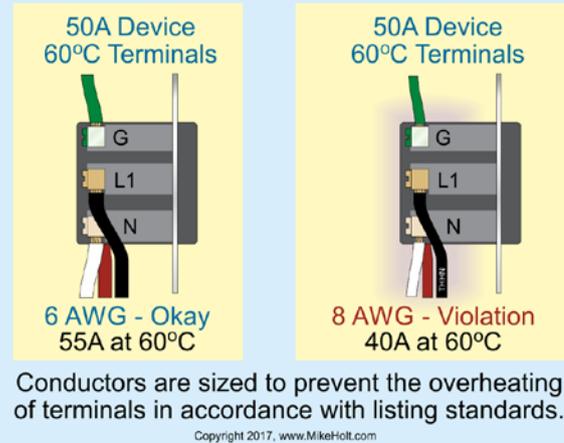


Figure 110–17

**Conductor Sizing, Equipment Rated 100A or Less
110.14(C)(1)(a)(3)**

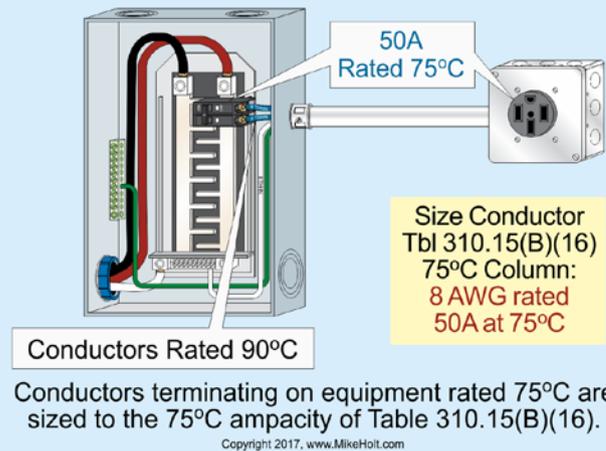


Figure 110–18

- (4) For motors marked with design letters B, C, or D, conductors having an insulation rating of 75°C or higher can be used, provided the ampacity of such conductors doesn't exceed the 75°C ampacity. [Figure 110–19](#)

(b) Equipment Rated Over 100A.

- (1) Conductors with an insulation temperature rating of 75°C must be sized to the 75°C temperature column of Table 310.15(B)(16). [Figure 110–20](#)

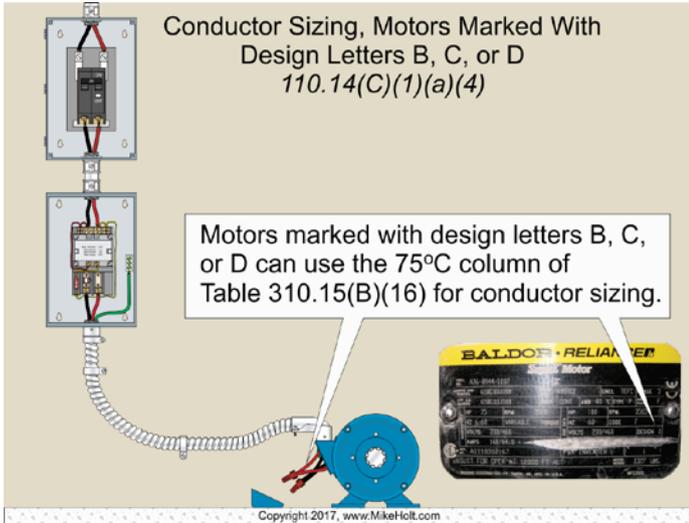


Figure 110-19

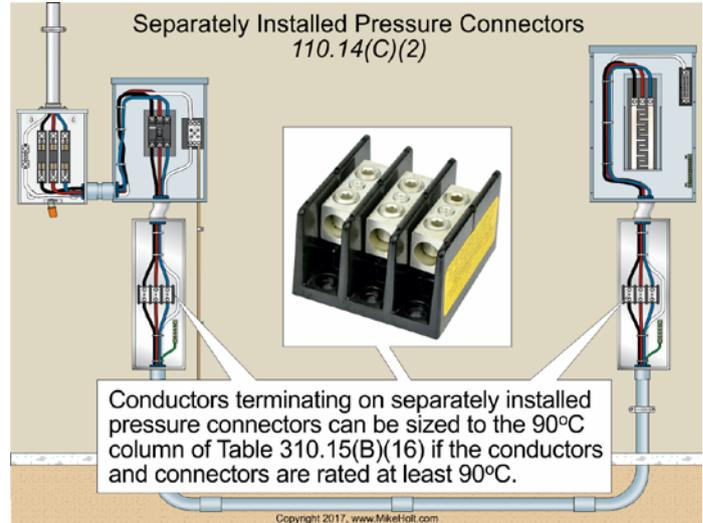


Figure 110-21

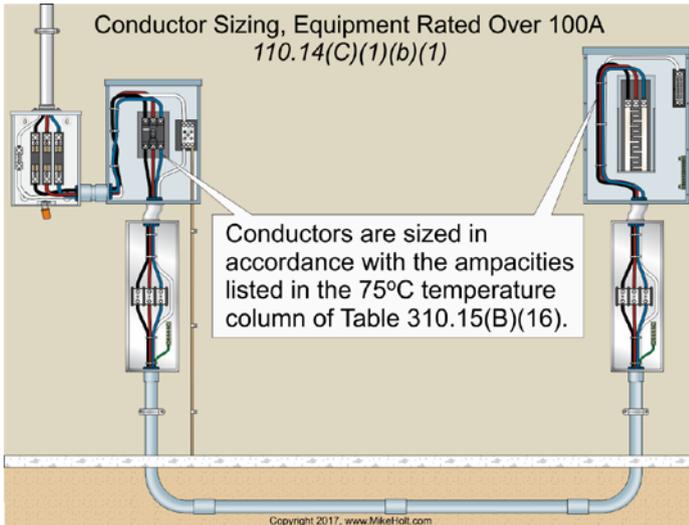


Figure 110-20

(2) Conductors with an insulation temperature rating of 90°C can be sized to the 75°C column of Table 310.15(B)(16).

(2) Separate Connector Provisions. Conductors can be sized to the 90°C column of Table 310.15(B)(16) if the conductors and pressure connectors are rated at least 90°C. [Figure 110-21](#)

Note: Equipment markings or listing information may restrict the sizing and temperature ratings of connected conductors.

(D) Torque. Where tightening torque values are indicated on equipment or installation instructions, a calibrated torque tool must be used to achieve the indicated torque value, unless the equipment manufacturer provides an alternative method of achieving the required torque.

Figure 110-22

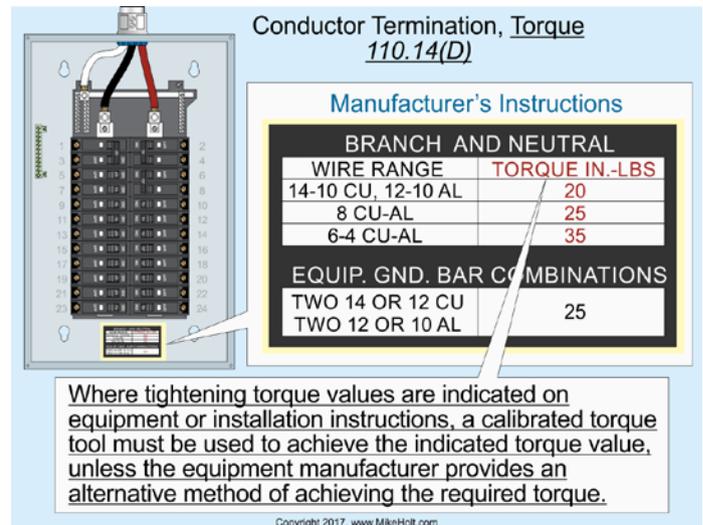


Figure 110-22

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 may also 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.

110.16 Arc-Flash Hazard Warning

The rules for warning qualified persons about arc-flash hazards have been increased, again.

Analysis



EXPANDED

Since arc-flash hazard warnings rules were added in 2002, they've been revised every *Code* cycle like clockwork. There's no question that the continued revisions are due to the fact that electrical safety is taken more seriously than ever before.

Many people who are concerned with worker safety have tried to increase this rule to require information, such as restricted and prohibited approach boundaries, incident energy, arc rating of clothing, and other related information. While those requirements didn't make it into this edition of the *NEC* others did, but only for larger pieces of equipment.

The change is that for other than dwelling units, the arc-flash label must indicate the voltage of the system, the available fault current, the clearing time of the overcurrent protection device(s), and the date the label was installed. The available fault current can be obtained from the electric utility or be calculated with proper field information, and the clearing time can be obtained from the manufacturer of the fuse or circuit breaker.

An exception was added to allow arc-flash labels that are installed "in accordance with acceptable industry practice," and an Informational Note was added to explain what that means. Basically, if you follow the guidelines of NFPA 70E as they relate to labels, you'll meet the new *Code* requirement.

Proponents of this change claim this new rule will result in a safer environment for the electrical worker, but opponents claim these changes shouldn't be in the *NEC* at all, as it's intended to be an installation standard, not a workplace safety standard.

110.16 Arc-Flash Hazard Warning

(A) Arc-Flash Hazard Warning Label. Switchboards, switchgear, panelboards, industrial control panels, meter socket enclosures, and motor control centers in other than dwelling units must be marked to warn qualified persons of the danger associated with an arc flash from short circuits or ground faults. The arc-flash hazard warning marking must be permanently affixed, have sufficient durability to withstand the environment involved [110.21(B)], and be clearly visible to qualified persons before they examine, adjust, service, or perform maintenance on the equipment. [Figure 110-23](#)

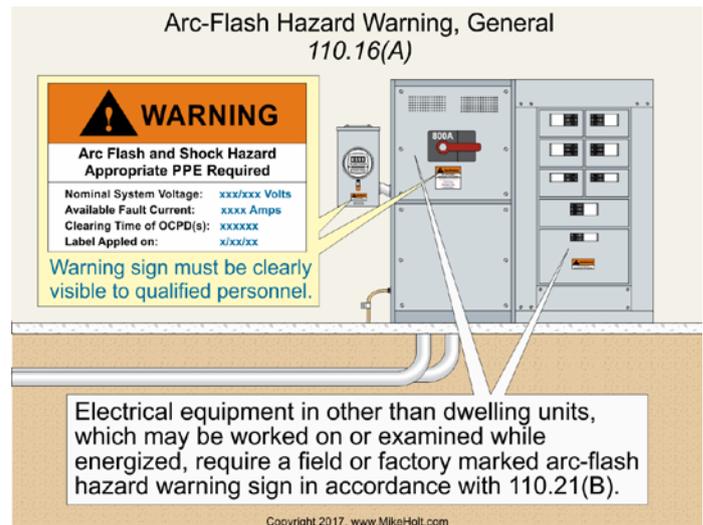


Figure 110-23

Author's Comment:

- See the definition of "Qualified Person" in Article 100.
- This rule is intended to warn qualified persons who work on energized electrical systems that an arc-flash hazard exists so they'll select proper personal protective equipment (PPE) in accordance with industry accepted safe work practice standards.

(B) Service Equipment Available Fault Current Label. [Service equipment rated 1,200A or more must have a field or factory installed label containing the following details and have sufficient durability to withstand the environment:](#) [Figure 110-24](#)



Figure 110–24

- (1) [Nominal system voltage](#)
- (2) [Available fault current at the service overcurrent protection device](#)
- (3) [Clearing time of the service overcurrent protection device based on the available fault current at the service equipment](#)
- (4) [Date the service equipment available fault current label was installed](#)

Ex: Service equipment labeling isn't required if an arc-flash label in accordance with NFPA 70E, Standard for Electrical Safety in the Workplace [see Note 3] is applied.

Note 1: NFPA 70E, *Standard for Electrical Safety in the Workplace*, provides guidance in determining the severity of potential exposure, planning safe work practices, arc-flash labeling, and selecting personal protective equipment.

Note No. 3: NFPA 70E, *Standard for Electrical Safety in the Workplace* provides specific criteria for developing arc-flash labels, such as nominal system voltage, incident energy levels, arc-flash boundaries, and selecting personal protective equipment.

110.21 Markings

New marking requirements for reconditioned equipment have been added, and the warning signage requirements have been editorially revised.

Analysis



NEW

Reconditioned Equipment. While the thought of “reconditioned” equipment may seem substandard at first, sometimes it really is the only option. We all long for a world where all of the electrical equipment in every building is brand new, but when you find yourself living in that world pinch yourself...because you're dreaming. In the real world equipment isn't brand new, and some equipment isn't even manufactured any more. When this is the case the only options are complete removal and replacement of a system or finding and using used or reconditioned equipment.

When reconditioned equipment is used, what are the rules? This issue hasn't been addressed in the *Code* until now. With these new changes, we now have requirements for marking the equipment by the company responsible for the reconditioning. This helps to ensure that a reputable company did the work. The date of refurbishing or reconditioning must be included, which gives additional information to the installer and to the AHJ, both of whom need to use judgment when deciding on the suitability of such a product.



CLARIFIED

Markings. Section 110.21(B) was revised to clarify that a combination of words, colors, and symbols can (and probably should) be used for caution, warning, or danger signs or labels. A literal reading of the 2014 edition of 110.21(B) could be construed as requiring words or colors or symbols, but not a combination of those three. Obviously this isn't, and wasn't, the intent.

110.21 Markings

(A) [Equipment Markings.](#)

(1) General. The manufacturer's name, trademark, or other descriptive marking must be placed on all electrical equipment and, where required by the *Code*, markings such as voltage, current, wattage, or other ratings must be provided. Marking must have sufficient durability to withstand the environment involved.

(2) Reconditioned Equipment. Reconditioned equipment must be marked with the name, trademark, or other descriptive marking by the organization responsible for reconditioning the electrical equipment, along with the date of the reconditioning.

Reconditioned equipment must be identified as “reconditioned” and approval of the reconditioned equipment isn’t based solely on the equipment’s original listing.

Ex: Reconditioning markings aren’t required in industrial occupancies, where conditions of maintenance and supervision ensure that only qualified persons service the equipment.

Note: Normal servicing of equipment isn’t to be considered to be reconditioning equipment.

(B) Field-Applied Hazard Markings. Where caution, warning, or danger signs or labels are required, the labels must meet the following:

- (1) The markings **must warn** of the **hazards** using effective words, colors, symbols, **or a combination of** words, colors, and symbols.

Figure 110–25



Figure 110–25

Note: ANSI Z535.4, *Product Safety Signs and Labels*, provides guidelines for the design and durability of signs and labels.

- (2) The label can’t be handwritten, and it must be permanently affixed to the equipment. Figure 110–26

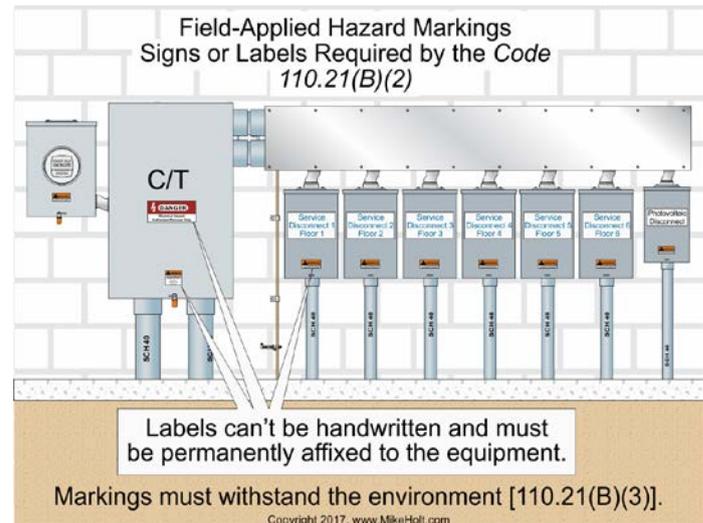


Figure 110–26

Ex to (2): Labels that contain information that’s likely to change can be handwritten, if it’s legible.

Author’s Comment:

- A permanently affixed sign includes a sticker, but not a piece of paper taped to the equipment.
- (3) The marking must be of sufficient durability to withstand the environment involved.

110.24 Available Fault Current

The available fault current calculation required by this section must now be made available upon request.

Analysis



EXPANDED

Using equipment that can handle the available fault current of an electrical system is one of the most important parts of a safe electrical installation. Determining the fault current rating of equipment for an installation can only be done after determining the available fault current at the line terminals of the equipment.

Calculating the available fault current at any given point in an electrical system is rather complicated and requires one to have knowledge and special training on this subject. Field marking of the maximum available fault current is an existing requirement. What's new to this edition of the *NEC*, is that the available fault current calculation must be made available upon request by the designer, installer, inspector, or those who operate or maintain the equipment.

Although the *Code* doesn't tell us how to make the information available, placing documentation in the equipment along with the panel schedule might not be a bad idea. This will ensure that not only the installer or inspector has access to it, but the future operator or maintenance personnel will as well.

110.24 Available Fault Current

(A) Field Marking. Service equipment, in other than dwelling units, must be field marked with the maximum available fault current, the date the fault current calculation was performed, and be of sufficient durability to withstand the environment involved. [The available fault current calculation for the service equipment label must be documented and be available to those who are authorized to design, install, inspect, maintain, or operate the system.](#) Figure 110-27

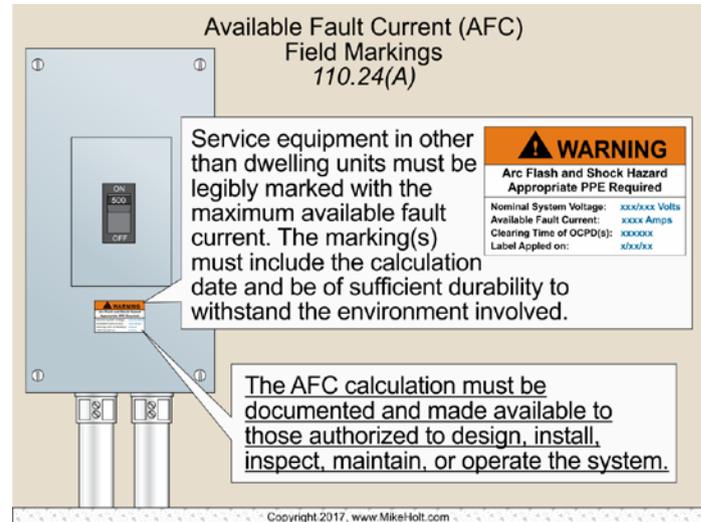


Figure 110-27

Note: The fault current markings required by this section are to ensure compliance with 110.9 and 110.10. They're not intended to be used for arc-flash analysis. Arc-flash hazard information is available in NFPA 70E, *Standard for Electrical Safety in the Workplace*.

(B) Modifications. When modifications to the electrical installation affect the maximum available fault current at the service, the maximum available fault current must be recalculated to ensure the service equipment ratings are sufficient for the maximum available fault current at the line terminals of the equipment. The required field marking(s) in 110.24(A) must be adjusted to reflect the new level of maximum available fault current.

Ex: Field markings aren't required for industrial installations where conditions of maintenance and supervision ensure that only qualified persons service the equipment.

110.26 Spaces About Electrical Equipment

Changes to 110.26 include a new Informational Note referring to NFPA 70E, *Standard for Electrical Safety in the Workplace*, new requirements for spaces with "limited access," and clarification to the outdoor dedicated space rules.

Analysis



NEW

Informational Note. Most of 110.26 is intended to provide safety for the electrical worker while working on energized equipment. This rule requires clear working space around equipment, it reminds people not to use the working space area for storage, provides rules on a viable escape route in case things go bad around large equipment, mandates illumination for equipment, and provides other safety provisions. Again, most of 110.26 relates to protecting the electrical worker who's working on energized equipment.

In this edition of the *NEC*, the new Informational Note tells the *Code* user to look to NFPA 70E to determine safe work practices, potential exposure, labeling of equipment, and the proper personal protective equipment. It's critical that the electrical the industry, electrician, inspector, contractor, and others follow the safe work practices identified in NFPA 70E as mandated by OSHA.



NEW

Above Suspended Ceilings. New to 2017 are rules for equipment that really can't meet the general working space requirements of 110.26. What do you do when a disconnect is located above a suspended ceiling and has to be there in order for it to be within sight of the equipment it supplies? It's impossible to get a 30 in. by 36 in. working space area in a ceiling grid that only has 24 in. by 48 in. openings. The 2017 change will allow the disconnect above the grid ceiling, but the equipment must be oriented so the depth of the working space required in Table 110.26(A) is satisfied.

This means that the disconnect needs to be mounted so that the 24-in. dimensions of the grid opening are to your left and right when facing the equipment, and the 48-in. dimensions must be in the front-to-back orientation. The equipment must be installed at the edge of the opening to ensure 36, 42, or 48 in. of space, as applicable.



NEW

Crawl Spaces. Installations in crawl spaces must have an access opening of 22 in. by 30 in., which happens to be the standard size of access to crawl spaces required by the International Building Code (IBC) and the International Residential Code (IRC). In addition to this access point, which only gets us into the crawlspace, we still need the required Table 110.26(A)(1) depth, but we don't have to meet the headroom requirements of 110.26(A)(3), which would typically be impossible.



CLARIFIED

Outdoor Equipment. The 2014 *NEC* created a new requirement for panelboards, switchboards, switchgear, and motor control centers installed outdoors to have dedicated electrical space, just like the indoor equipment requirements. As is usually the case, when you write a new rule you need to revise it and address the (sometimes embarrassingly) obvious things you didn't originally consider. This time it's the roof overhangs. Imagine installing a meter and service disconnect on a building, only to be told that you now need to cut out a space in the roof eaves so nothing is above your equipment. Well, you don't need to worry about that any longer.

Part II. 1,000V, Nominal, or Less

110.26 Spaces About Electrical Equipment

For the purpose of safe operation and maintenance of equipment, access and working space must be provided about all electrical equipment. [Figure 110-28](#)

(A) Working Space. Equipment that may need examination, adjustment, servicing, or maintenance while energized must have working space provided in accordance with 110.26(1), (2), (3), [and \(4\)](#):

Author's Comment:

- The phrase "while energized" is the root of many debates. As always, check with the AHJ to see what equipment he or she believes needs a clear working space.



Figure 110-28

Note: NFPA 70E, *Standard for Electrical Safety in the Workplace*, provides guidance in determining the severity of potential exposure, planning safe work practices, arc-flash labeling, and selecting personal protective equipment.

(1) Depth of Working Space. The working space, which is measured from the enclosure front, isn't permitted to be less than the distances contained in Table 110.26(A)(1). Figure 110-29

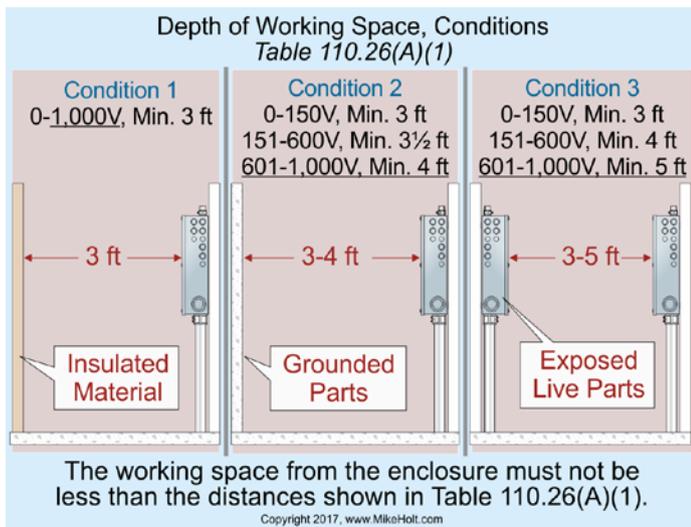


Figure 110-29

Voltage-to-Ground	Condition 1	Condition 2	Condition 3
0-150V	3 ft	3 ft	3 ft
151- 600V	3 ft	3½ft	4 ft
601- 1,000V	3 ft	4 ft	5 ft

(a) Rear and Sides. Working space isn't required for the back or sides of assemblies where all connections and all renewable or adjustable parts are accessible from the front. Figure 110-30



Figure 110-30

(b) Low Voltage. If special permission is granted in accordance with 90.4, working space for equipment that operates at not more than 30V ac or 60V dc can be less than the distance in Table 110.26(A)(1).

Figure 110-31

Author's Comment:

- See the definition of "Special Permission" in Article 100.

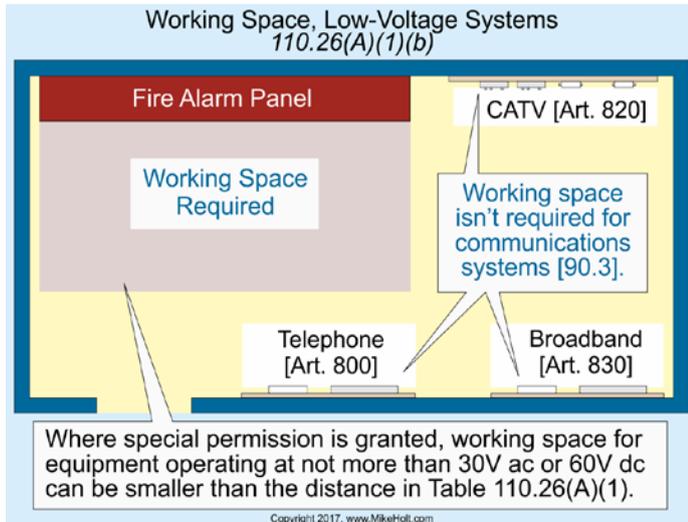


Figure 110-31

(c) Existing Buildings. If electrical equipment is being replaced, Condition 2 working space is permitted between dead-front switchboards, switchgear, panelboards, or motor control centers located across the aisle from each other where conditions of maintenance and supervision ensure that written procedures have been adopted to prohibit equipment on both sides of the aisle from being open at the same time, and only authorized, qualified persons will service the installation.

Author's Comment:

- The working space requirements of 110.26 don't apply to equipment included in Chapter 8—Communications Circuits [90.3].

(2) Width of Working Space. The width of the working space must be a minimum of 30 in., but in no case less than the width of the equipment. [Figure 110-32](#)

Author's Comment:

- The width of the working space can be measured from left-to-right, from right-to-left, or simply centered on the equipment, and can overlap the working space for other electrical equipment. [Figure 110-33](#)

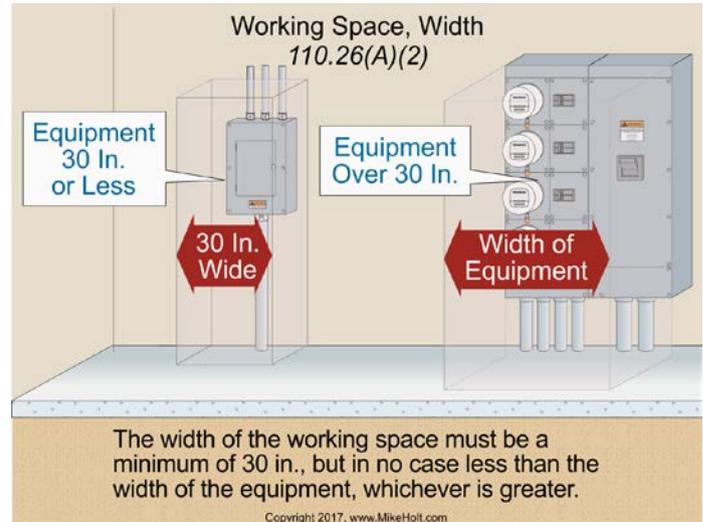


Figure 110-32

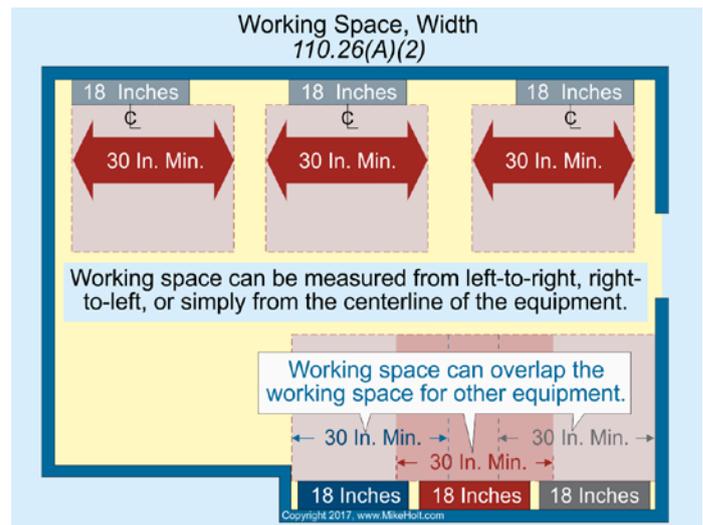


Figure 110-33

The working space must be of sufficient width, depth, and height to permit all equipment doors to open 90 degrees. [Figure 110-34](#)

(3) Height of Working Space (Headroom). The height of the working space in front of equipment isn't permitted to be less than 6½ ft, measured from the grade, floor, platform, or the equipment height, whichever is greater. [Figure 110-35](#)

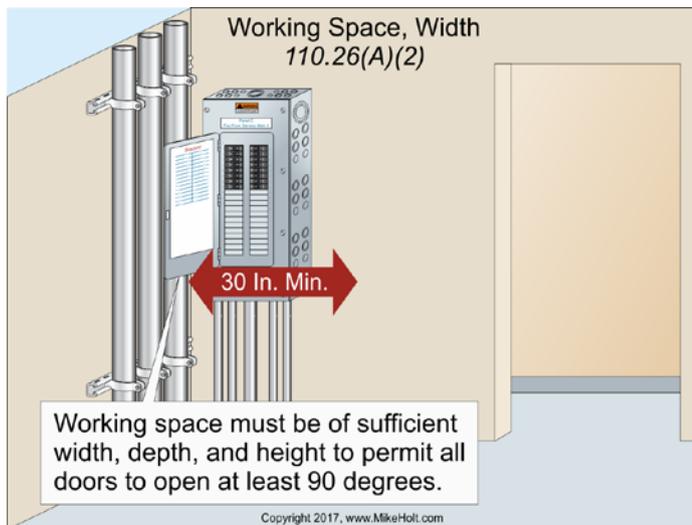


Figure 110-34

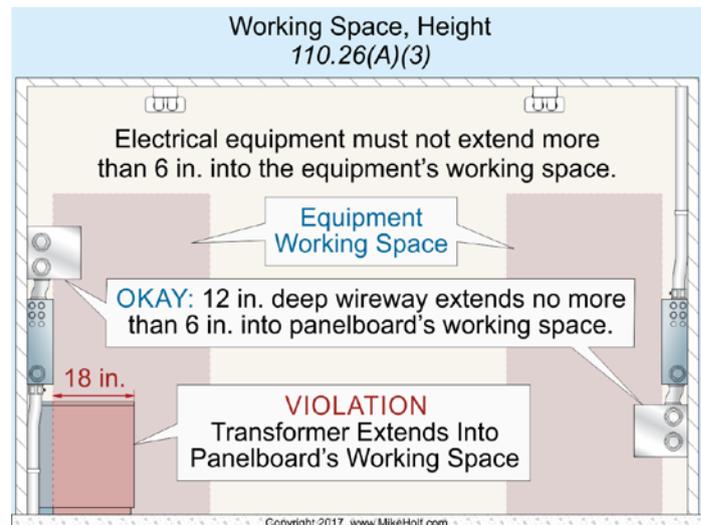


Figure 110-36

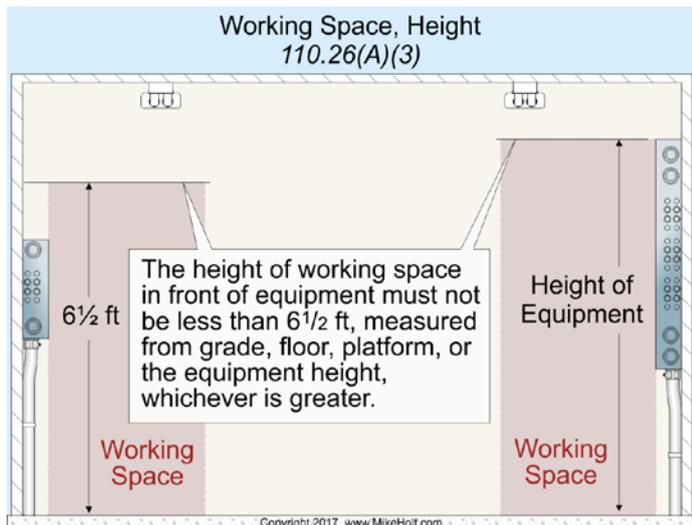


Figure 110-35

Equipment such as raceways, cables, wireways, cabinets, panels, and so on, can be located above or below electrical equipment, but must not extend more than 6 in. into the equipment's working space. [Figure 110-36](#)

Ex 1: The minimum headroom requirement doesn't apply to service equipment or panelboards rated 200A or less located in an existing dwelling unit.

Author's Comment:

- See the definition of "Dwelling Unit" in Article 100.

Ex 2: Meters are permitted to extend beyond the other equipment.

Ex 3: For battery systems, see 480.10(D) for top clearance requirements.

(4) Limited Access. Where equipment is likely to require examination, adjustment, servicing, or maintenance while energized is located in a space with limited access, all of the following conditions apply:

- (a)(1) Above Suspended Ceiling. Equipment installed above a suspended ceiling must have an access opening not smaller than 22 in. x 22 in.
- (a)(2) Crawl Space. Equipment installed in a crawl space must have an accessible opening not smaller than 22 in. x 30 in.
- (b) The width of the working space must be a minimum of 30 in., but in no case less than the width of the equipment.
- (c) The working space must permit equipment doors to open 90 degrees.
- (d) The working space in front of the equipment must comply with the depth requirements of Table 110.26(A)(1), and horizontal ceiling structural members are permitted in this space.

(B) Clear Working Space. The working space required by this section must be clear at all times. Therefore, this space isn't permitted for storage. [Figure 110-37](#)

When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or open space, must be suitably guarded.

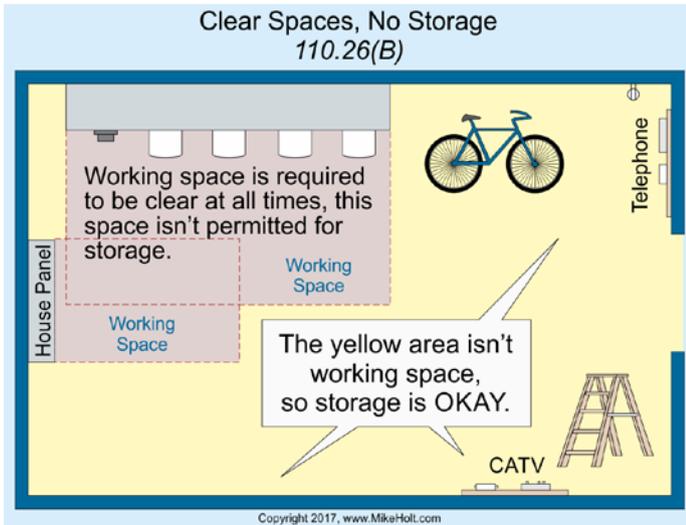


Figure 110-37

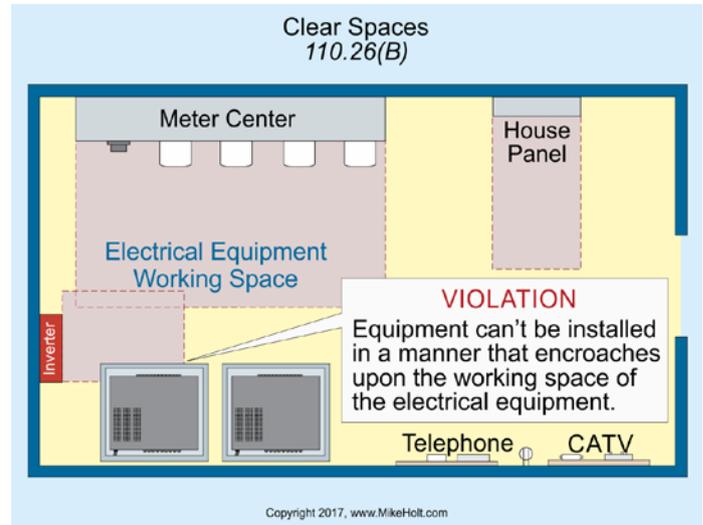


Figure 110-38

Author's Comment:

- When working in a passageway, the working space should be guarded from occupants using it. When working on electrical equipment in a passageway one must be mindful of a fire alarm evacuation with numerous occupants congregated and moving through the area.

CAUTION: *It's very dangerous to service energized parts in the first place, and it's unacceptable to be subjected to additional dangers by working around bicycles, boxes, crates, appliances, and other impediments.*

Author's Comment:

- Signaling and communications equipment aren't permitted to be installed in a manner that encroaches on the working space of the electrical equipment. [Figure 110-38](#)

(C) Entrance to and Egress from Working Space.

(1) Minimum Required. At least one entrance of sufficient area must provide access to and egress from the working space.

Author's Comment:

- Check to see what the authority having jurisdiction considers "Sufficient Area." Building codes contain minimum dimensions for doors and openings for personnel travel.

(2) Large Equipment. An entrance to and egress from each end of the working space of electrical equipment rated 1,200A or more that's over 6 ft wide is required. The opening must be a minimum of 24 in. wide and 6½ ft high. [Figure 110-39](#)

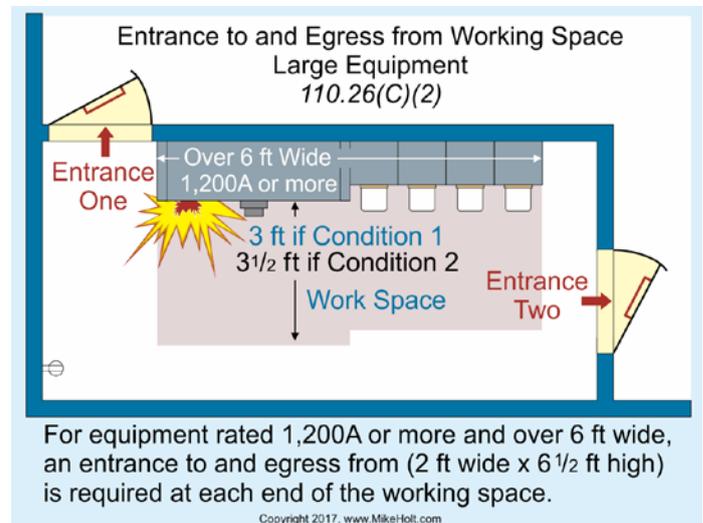


Figure 110-39

A single entrance to and egress from the required working space is permitted where either of the following conditions is met:

(a) Unobstructed Egress. Only one entrance is required where the location permits a continuous and unobstructed way of egress travel.

[Figure 110-40](#)

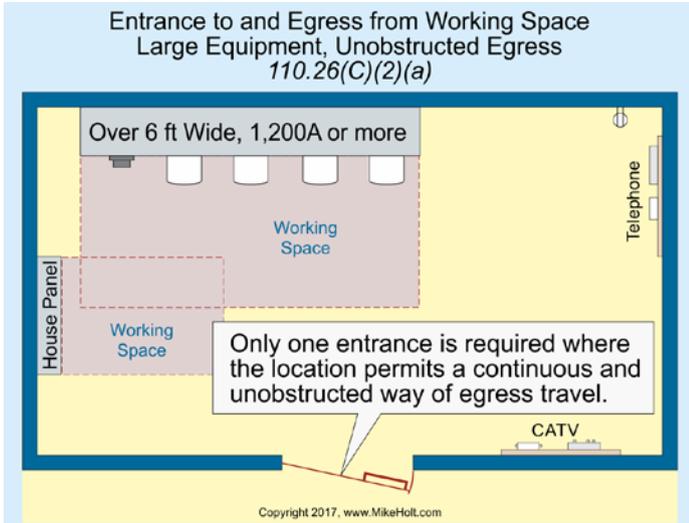


Figure 110-40

(b) Double Workspace. Only one entrance is required where the required working space depth is doubled, and the equipment is located so the edge of the entrance is no closer than the required working space distance. Figure 110-41

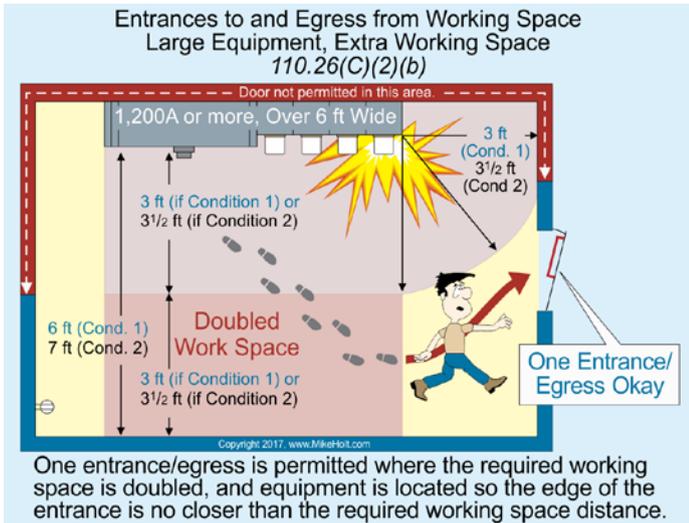


Figure 110-41

(3) Personnel Doors. If equipment with overcurrent or switching devices rated 800A or more is installed, personnel door(s) for entrance to and egress from the working space located less than 25 ft from the nearest edge of the working space must have the door(s) open in the direction of egress and be equipped with listed panic hardware. Figure 110-42

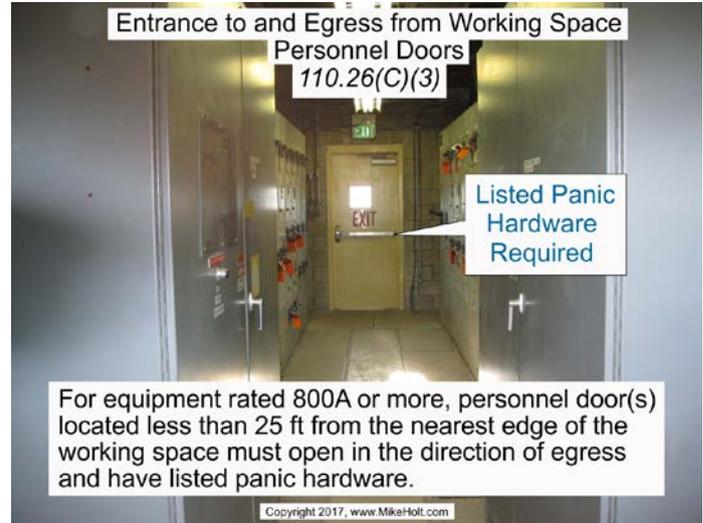


Figure 110-42

Author's Comment:

- History has shown that electricians who suffer burns on their hands in electrical arc-flash or arc-blast events often can't open doors equipped with knobs that must be turned.
- Since this requirement is in the *NEC*, the electrical contractor is responsible for ensuring that panic hardware is installed where required. Some are offended at being held liable for nonelectrical responsibilities, but this rule is designed to save the lives of electricians. For this and other reasons, many construction professionals routinely hold "pre-construction" or "pre-con" meetings to review potential opportunities for miscommunication—before the work begins.

(D) Illumination. Service equipment, switchboards, switchgear, and panelboards, as well as motor control centers located indoors must have illumination located indoors controlled by manual means; automatic control without manual control isn't permitted. Figure 110-43

Author's Comment:

- The *Code* doesn't provide the minimum foot-candles required to provide proper illumination. Proper illumination of electrical equipment rooms is essential for the safety of those qualified to work on such equipment.

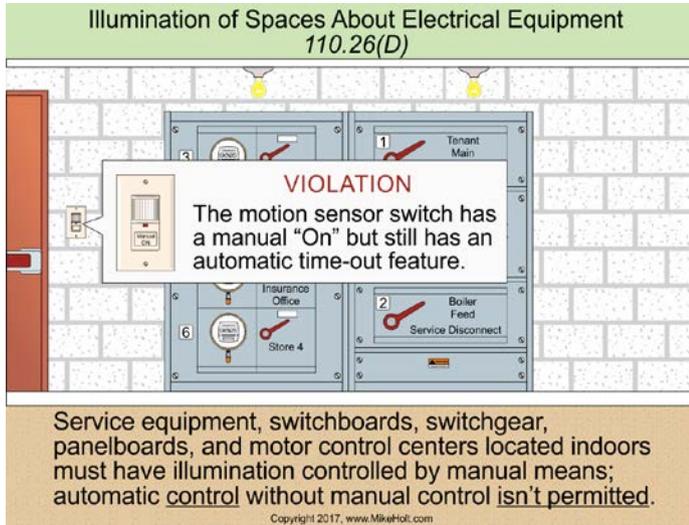


Figure 110-43

(E) Dedicated Equipment Space. Switchboards, switchgear, panelboards, and motor control centers must have dedicated equipment space and be protected from damage as follows:

(1) Indoors.

(a) Dedicated Electrical Space. The footprint space (width and depth of the equipment) extending from the floor to a height of 6 ft above the equipment or to the structural ceiling, whichever is lower, must be dedicated for the electrical installation. [Figure 110-44](#)

No piping, ducts, or other equipment foreign to the electrical installation can be installed in this dedicated footprint space. [Figure 110-45](#)

Ex: Suspended ceilings with removable panels can be within the dedicated footprint space [110.26(E)(1)(d)].

Author's Comment:

- Electrical raceways and cables not associated with the dedicated space can be within the dedicated space. These aren't considered "equipment foreign to the electrical installation." [Figure 110-46](#)

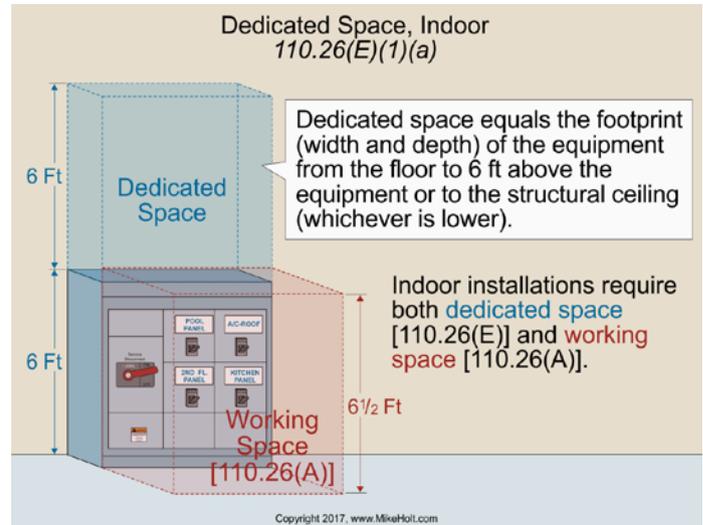


Figure 110-44

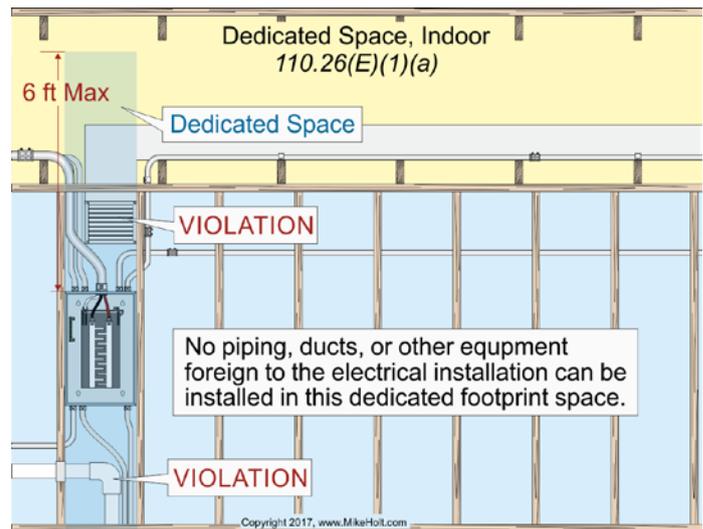


Figure 110-45

(b) Foreign Systems. Foreign systems can be located above the dedicated space if protection is installed to prevent damage to the electrical equipment from condensation, leaks, or breaks in the foreign systems, such protection can be as simple as a drip-pan. [Figure 110-47](#)

(c) Sprinkler Protection. Sprinkler protection piping isn't permitted in the dedicated space, but the *NEC* doesn't prohibit sprinklers from spraying water on electrical equipment.

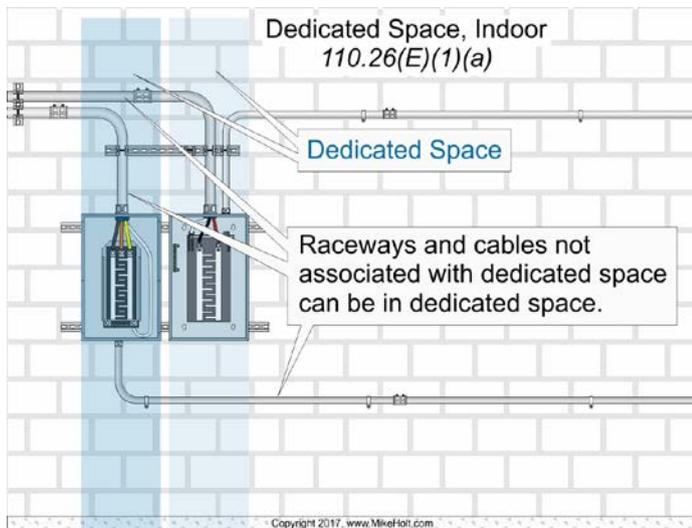


Figure 110-46

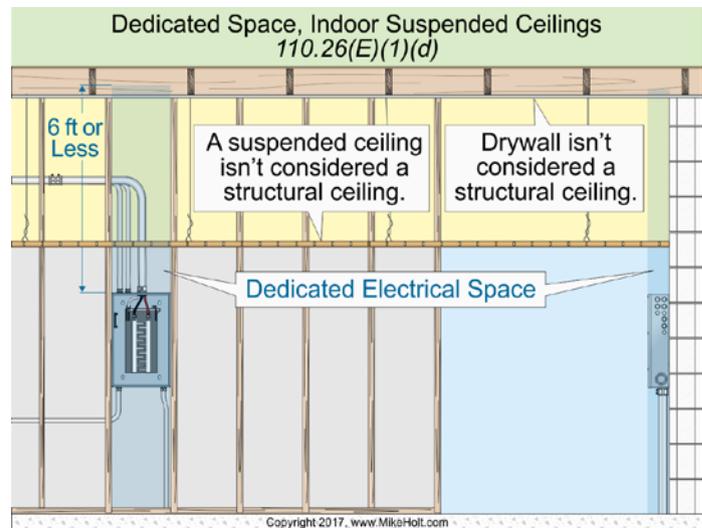


Figure 110-48

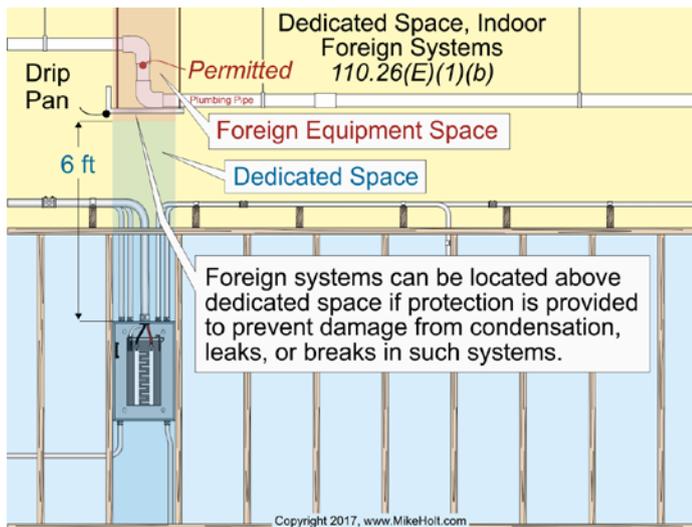


Figure 110-47

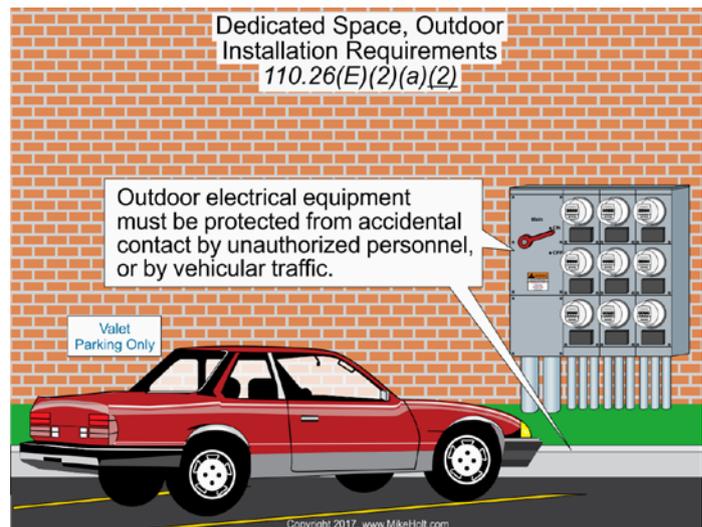


Figure 110-49

(d) Suspended Ceilings. A dropped, suspended, or similar ceiling isn't considered a structural ceiling. [Figure 110-48](#)

(2) Outdoor. Outdoor installations must comply with the following:

(a) Installation Requirements. Switchboards, switchgear, panelboards, and motor control centers installed outdoors must be:

- (1) Installed in [identified](#) enclosures
- (2) Protected from accidental contact by unauthorized personnel, or by vehicular traffic [Figure 110-49](#)
- (3) Protected by accidental spillage or leakage from piping systems

(b) Work Space. Switchboards, switchgear, panelboards, and motor control centers installed outdoors must have sufficient [working space clearance in accordance with 110.26\(A\)](#). [No architectural appurtenance or other equipment is permitted in the work space.](#)

(c) Dedicated Equipment Space Outdoor. The footprint space (width and depth of the equipment) extending from grade to a height of 6 ft above the equipment must be dedicated for the electrical installation. No piping, ducts, or other equipment foreign to the electrical installation can be installed in this dedicated footprint space. [Figure 110-50](#)



Figure 110-50

Author's Comment:

- See the definition of "Accessible (as applied to equipment)" in Article 100.

(F) Locked Electrical Equipment Rooms or Enclosures. Electrical equipment rooms or enclosures containing electrical apparatus controlled by a lock(s) are considered accessible to qualified persons.

Figure 110-51

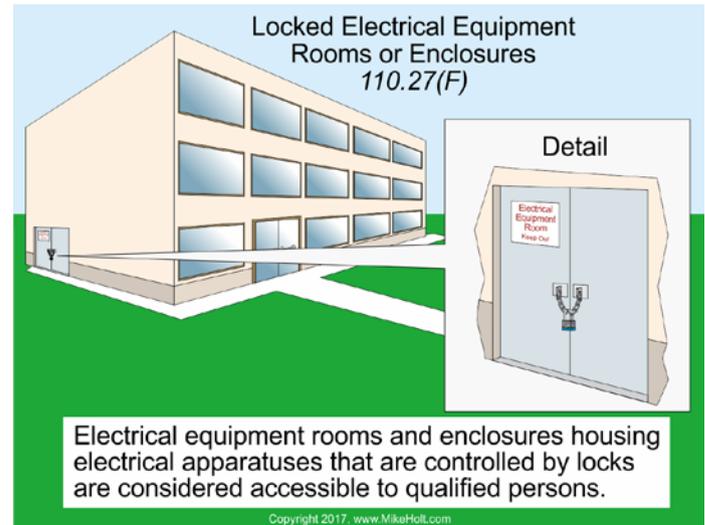


Figure 110-51