PDHonline Course E429 (3 PDH)

Revisions for the 2014 National Electrical Code® - Part 2

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Revisions for the 2014 NEC®, Part 2

PDH Course E429

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PDH Course E429

Revisions for the 2014 National Electrical Code® Part 2

Patrick S. Ouillette, P.E.

Introduction

Part 2 of this 3-part series covers Article 250 through Article 424. The course covers only major Code changes, but provides depth of coverage.

The layout and the method of presentation will enable new Code users to navigate through the changes. Those well experienced in the Code will find depth in the coverage. Through the heading(s) at the beginning of each Code change addressed in the document, the reader will readily identify the section affected by the change and the specific subject being discussed. The Significance section serves as an introduction to the Code change under discussion. An Analysis of the Code change follows, with explanation as necessary to help the student understand the revision, its background, and the logic of the change. Graphics, photographs, examples, or calculations are used to illustrate the change and to enhance learning. The Summary is a brief re-statement of the highlights of the Code change. An Application Question, with Answer and key to the correct answer, is included at the end of each Code section studied for exercise in applying the change and to broaden learning. Many of the sections analyzed contain a Code Refresher that addresses existing Code requirements related to the change. The author attempts to tie the entire NEC® together through the study of the changes.

Although there are many references to the 2014 *NEC* throughout this document, the course and quiz can be completed without the need to refer to the *NEC* itself. For further study on any Code section within this course, the 2014 *NEC* should be consulted.

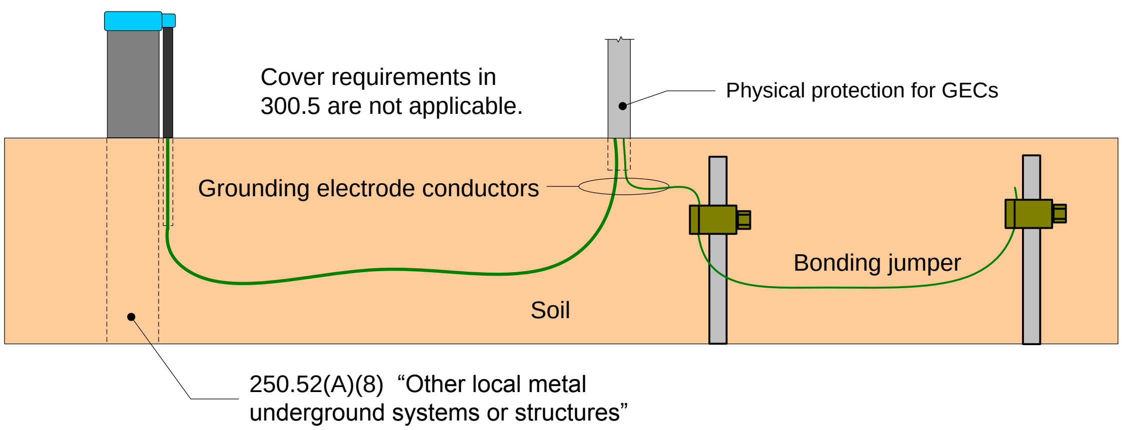
Grounding Electrode Conductor Installation – Securing and Protection Against Physical Damage

Significance

This change will clarify the requirements for installing grounding electrode conductors and grounding electrode bonding jumpers underground.

Analysis

Table 300.5 Minimum Cover Requirements, 0 to 1000 Volts, Nominal, Buried in Millimeters (Inches) contains cover depths for various wiring methods installed in seven location categories. Direct burial cables and conductors must be buried 18 in. or 24 in., depending on the location of the wiring. This Code revision clarifies that this requirement does not apply to grounding electrode conductors (GECs) or grounding electrode bonding jumpers connecting to any type of qualified grounding electrode(s). The intent may have been to exempt GECs and grounding electrode bonding jumpers from only the cover requirements in 300.5(A), but the Code language is "Grounding electrode conductors and grounding electrode bonding jumpers shall not be required to comply with 300.5." Section 300.5 contains many subsections. Some of these subsections are clearly not applicable, while (F) Backfill contains requirements for proper underground raceway and cable installations.



Summary

Grounding electrode conductors and grounding electrode bonding jumpers are not required to comply with Section 300.5.

Application Question

Section 300.5(D)(1) Emerging from Grade requires protective enclosures or raceways down to the minimum cover depth in Table 300.5 for direct-buried conductors emerging from grade. Does this provision apply to GECs?

Answer

No. Since the depth requirement is not applicable, neither is the protective enclosure required to extend down to the Table 300.5 depth. This is one of the items that the Code panel is attempting to clarify. Section 250.64(B) provides for protection against physical damage for GECs.

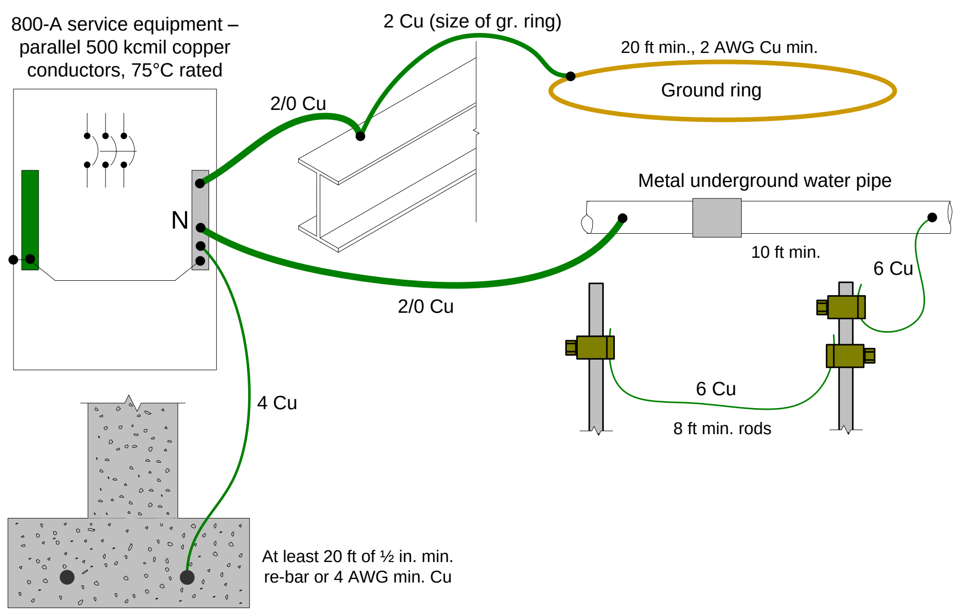
Size of Alternating-Current Grounding Electrode Conductor – Connections to a Rod, Pipe, or Plate Electrode(s) – Connections to Concrete-Encased Electrodes

Significance

This revision seeks to clarify the meaning of "sole connection" to a grounding electrode.

Analysis

The size of the ac grounding electrode conductor (GEC) is based on the size of the service-entrance conductors, or equivalent area for parallel conductors, and the effectiveness of the grounding electrode(s) the electrical system is connected to. The resistance to earth of a ground rod is generally higher than that for underground metal water piping. Consequently, a ground rod, or pair of ground rods, requires only a 6 AWG Cu GEC, while the GEC that connects to underground metal water piping could be required to be as large as 3/0 Cu, depending on the size of the service-entrance conductors. Generally, the "sole connection" to an electrode is the only connection to the electrode—the electrode is not used to interconnect electrodes. The GEC connection to the ground ring, concrete-encased electrode, and ground rods in the diagram below is the sole connection to these electrodes. Connection to a single or multiple rod, pipe, or plate electrode(s) still only requires a 6 AWG Cu GEC to the first electrode in the sequence or between electrodes. The same is true where more than one concrete-encased electrode is used—4 AWG to the first electrode and between electrodes. Sole connection has a different meaning for these electrodes.



Summary

Connection to a single or multiple rod, pipe, or plate electrode(s), or to a single or multiple concrete-encased electrode(s) does not increase the size of the minimum required GEC specified for these electrodes. The "sole connection" sizing provisions are not forfeited.

Application Question: In the above diagram, is the 6 AWG Cu that connects from the water pipe to the ground rod the sole connection to the rod?

Answer: Yes. For the purpose of sizing GECs in 250.66, it is considered the sole connection.

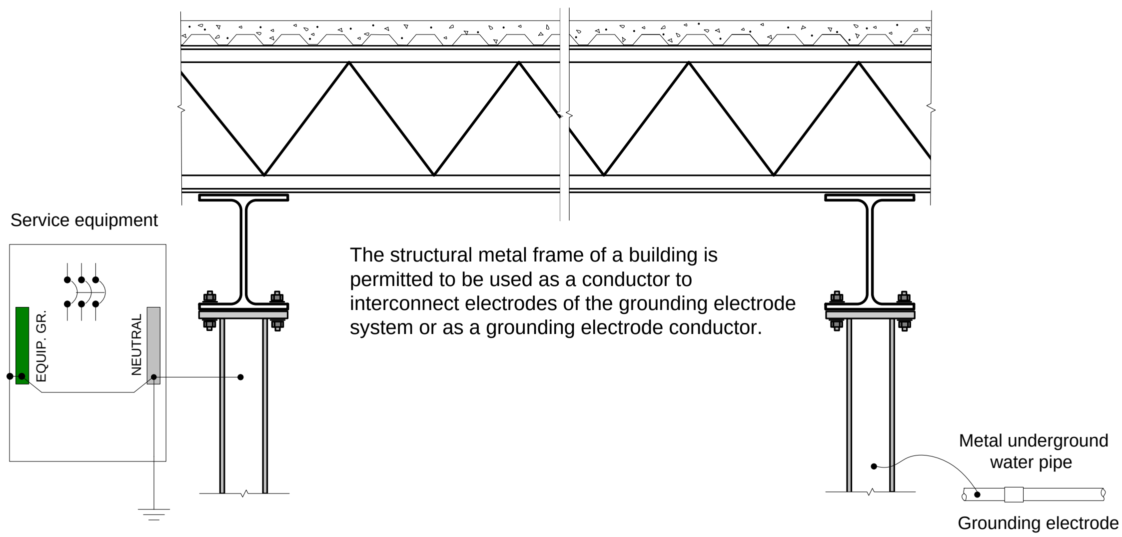
Grounding Electrode Conductor and Bonding Jumper Connection to Grounding Electrodes – Grounding Electrode Connections

Significance

The structural metal frame of a building can serve several grounding and bonding functions.

Analysis

The structural metal frame of a building is permitted to be used as a conductor to interconnect electrodes of the grounding electrode system or as a grounding electrode conductor (GEC), regardless of whether the metal frame itself qualifies as a grounding electrode. In the 2011 Code, the building frame had to qualify as a grounding electrode, by connection to a grounding electrode, in order to be used to interconnect electrodes or as a GEC. The change seems inconsequential, though, since using building steel to connect to a grounding electrode or to interconnect electrodes qualifies the building as an electrode according to the 2011 *NEC*. Remember that the *NEC* is not a design manual [90.1(A)]. The effectiveness of the building steel fault path must be considered, e.g., joints between steel members, length of fault path, etc.



Summary

The structural metal frame of a building is permitted to be used as a conductor to interconnect electrodes of the grounding electrode system or as a grounding electrode conductor, regardless of whether the metal frame itself qualifies as a grounding electrode.

Application Question

Does the first 5 ft of metal water piping, from the point of entrance into a building, have to qualify as a grounding electrode in order to be used to interconnect grounding electrodes?

Answer

No. The underground water service piping could be non-conductive and the rule will still apply. The rule is the same for the structural metal frame of a building.

Code Refresher

- ✓ In other than dwelling occupancies, exposed metal water piping can be used to interconnect electrodes or as a GEC. The 5 ft limitation does not apply. [250.68(C)(1), Exc.]

Grounding Electrode Conductor and Bonding Jumper Connection to Grounding Electrodes – Grounding Electrode Connections – A concrete-encased electrode…

Significance

This change provides guidance and clarification concerning a permitted method for connecting to a concrete-encased electrode.

Analysis

The lack of bonding an available concrete-encased electrode to the grounding electrode system is a common *NEC* violation in some jurisdictions. If the wireman does not expect to be on site before concrete pouring, he should make arrangements with the general contractor or concrete contractor to provide a means for connecting the service neutral to the concrete-encased electrode. This Code change clarifies that a reinforcing bar or copper wire type concrete-encased electrode installed in accordance with 250.52(A)(3) can be extended from the location within the concrete to an accessible location above the concrete to accommodate connection to the service.

The reinforcing bar extension (or "stub-up") or copper conductor should exit the concrete in a location protected from the weather. The American Concrete Institute Standard 318 (ACI 318), *Building Code Requirements for Reinforced Concrete*, requires a certain thickness of concrete protection over structural reinforcing bars for reinforced concrete surfaces exposed to weather or in direct contact with earth. The portion of a structural reinforcing bar protruding from the concrete wall to facilitate connection to the electrical service neutral is not performing a structural function, but should be protected from corrosion to ensure the integrity of the electrical connection.

This 4 AWG copper grounding electrode conductor is connected to reinforcing bars in the concrete footing and emerges at the top of the concrete foundation wall through the hole in the wood sill plate.

This 4 AWG copper grounding electrode conductor connects to the neutral bus in the service panel directly above, passes through the clamp in the box out at the top of the concrete wall, then connects to ground rods.

Summary

A concrete-encased electrode of either the conductor type or reinforcing bar, extended from the location within the concrete to an accessible location above the concrete wall, is a permitted method for facilitating the grounding of the service neutral to the concrete-encased electrode.

Application Question

Where a concrete-encased electrode consists of a minimum of 20 ft of copper conductor, or where a copper conductor is connected to reinforcing bars in a concrete footing and run to a location above the concrete wall, what minimum conductor size is required?

Answer

The minimum required size is 4 AWG copper.

More on Concrete-Encased Electrodes (Ufer ground)

The National Electrical Code permits grounding electrodes consisting of concrete-encased reinforcing bars or at least 20 ft of bare copper not smaller than 4 AWG placed near the bottom of a foundation footing, or placed horizontally or vertically in a foundation wall. The concrete wall must be in contact with earth for the encased steel or copper to be an effective grounding means. This rules out any portion of the concrete electrode that is above grade. Also, that area of the concrete-encased electrode in contact with frozen ground or dry ground is less effective for grounding. Hence, the preferred location of reinforcing steel or bare copper is near the bottom of a support foundation footing. When a foam or plastic barrier is placed between the concrete-encased steel or copper and earth, the installation does not qualify as a concrete-encased electrode. Other barriers and coatings may also prevent direct contact between concrete and earth.

Code Refresher

- ✓ The *NEC* permits a 6 AWG copper grounding electrode conductor for connection to a rod, pipe, or plate electrode regardless of the size of the ungrounded service conductors. This is due to the fact that the rod-to-earth contact resistance and the earth resistance will limit any current to earth to a level that can be safely carried by the 6 AWG copper. For certain size services, the minimum required size for GECs that are the sole connection to rod, pipe, or plate electrodes, concrete-encased electrodes, and ground rings is smaller than specified in Table 250.66. The GEC size specified in Table 250.66 shall not be reduced when the grounding electrode is a metal underground water pipe, the metal frame of a building, other listed electrodes (see the listing requirements), and other local metal underground systems or structures (e.g., a well casing). The largest GEC required by the Code for any size service is 3/0 copper.

  Even though a 3/0 copper conductor is the largest GEC required by Code, there is no upper limit on the required size of the equipment grounding conductor. An equipment grounding conductor performs a different function than a grounding electrode conductor. Note that a 3/0 copper equipment grounding conductor is suitable for equipment supplied by a 1200-amp overcurrent device. For circuits of higher rating, a larger equipment grounding conductor is required in accordance with Table 250.122.

Bonding Conductors and Jumpers – Size – Supply-Side Bonding Jumper

Significance

Instead of using Table 250.66 for sizing supply-side bonding jumpers and certain grounded conductors, new Table 250.102(C)(1) has been added to the *NEC* for this purpose.

Analysis

In the 2011 and previous Code editions, several sections referenced Table 260.66 for sizing jumpers and grounded conductors on the supply side of a service disconnecting means or the first disconnecting means for a separately derived system. These conductors and jumpers form the link between the equipment grounding conductors and the neutral/grounded conductor for the fault-clearing path. Correct sizing is important, since these conductors may have to carry significant fault current. The reference to "supply side" means that there is no overcurrent device upstream except for the utility's overcurrent device. In the case of separately derived systems, however, there may be an overcurrent device installed upstream that is within the purview of the NEC, e.g., the primary OCPD for a transformer-supplied separately derived system.

Revised Section 250.28(D)(1) now refers the Code user to Table 250.102(C)(1) for sizing the main bonding jumper and system bonding jumper. Section 250.24(C)(1) refers the user to the new table for the minimum size of the grounded conductor required to be run to the first disconnecting means. Section 250.30(A)(3)(a) contains a similar requirement that applies to separately derived systems. Sections 250.102(C)(1) and (C)(2) have been revised to reflect the change, and Section 250.102(C)(3) has been deleted and replaced by Note 2 to the new table.

Note 1 to Table 250.102(C)(1) specifies a multiplier of 0.125 (12½%) for sizing grounded conductors and bonding jumpers for supply conductors over 1100 kcmil copper and 1750 kcmil aluminum. Note 2 provides requirements for sizing conductors and jumpers where the ungrounded supply conductors are of different materials (copper, aluminum, or copper-clad aluminum) than the jumpers. Notes 3 and 4 explain how to perform the sizing where there are multiple sets of ungrounded supply conductors or no supply conductors, e.g., busway.

The change is appropriate, since the title of Table 250.66 is "Grounding Electrode Conductor for Alternating-Current Systems." The grounding electrode conductor (GEC) connects to earth and performs a very different function that the conductors and jumpers addressed in the new table. A GEC is not intended to serve as a fault-clearing conductor. Also, the largest size copper and aluminum GECs required by Table 250.66 are 3/0 and 250 kcmil respectively, which is smaller than what is required for some supply-side jumpers and grounded conductors.

Summary

Previous Code references to Table 250.66 for sizing supply-side bonding jumpers and certain grounded conductors now refer to new Table 250.102(C)(1). These include sizing for grounded conductors run to the first disconnecting means for utility services and separately derived systems (even when no neutral loads are supplied), and for the main bonding jumper and system bonding jumper.

Application Question: What minimum size copper main bonding jumper is required to connect the neutral bar to the equipment grounding bar of a switchboard rated 1600 A? The switchboard is supplied with four sets of 600 kcmil copper conductors in parallel.

Answer: 300 kcmil copper (4 x 600 kcmil = 2400 kcmil; 2400 x 0.125 = 300)

Table 250.102(C)(1) Grounded Conductor, Main Bonding Jumper, System Bonding Jumper, and Supply-Side Bonding Jumper for Alternating-Current Systems

[a] For the purposes of this table, the term bonding jumper refers to main bonding jumpers, system bonding jumpers, and supply-side bonding jumpers.

Size of Largest Ungrounded Conductor or Equivalent Area for Parallel Conductors (AWG/kcmil)		Size of Grounded Conductor or Bonding Jumper[a] (AWG/kcmil)	
Copper	**Aluminum or Copper-Clad Aluminum**	**Copper**	**Aluminum or Copper-Clad Aluminum**
2 or smaller	1/0 or smaller	8	6
1 or 1/0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250	4	2
Over 3/0 through 350	Over 250 through 500	2	1/0
Over 350 through 600	Over 500 through 900	1/0	3/0
Over 600 through 1100	Over 900 through 1750	2/0	4/0
Over 1100	Over 1750	See Notes	

Code Refresher

- ✓ **250.28(A) and (B)** The purpose of the green-colored machine screw supplied with many panelboards that are listed for use as service equipment is to function as the main bonding jumper. It is sized to be Code compliant. If the enclosure accidentally becomes energized by contact with an ungrounded (hot) service conductor, this green screw (main bonding jumper) will be the link in the fault-clearing path that connects the enclosure to the neutral of the supply.
- ✓ **250.24(A)(4)** The grounding electrode conductor is not permitted to be connected to the equipment grounding bar unless the equipment bar is connected to the neutral bar with a wire or busbar (not where the main bonding jumper is a green-colored screw).
- ✓ **Article 100 – Definitions: Bonding Jumper, System** A system bonding jumper applies only to separately derived systems. It serves the same purpose as a main bonding jumper at a service supplied by a utility.

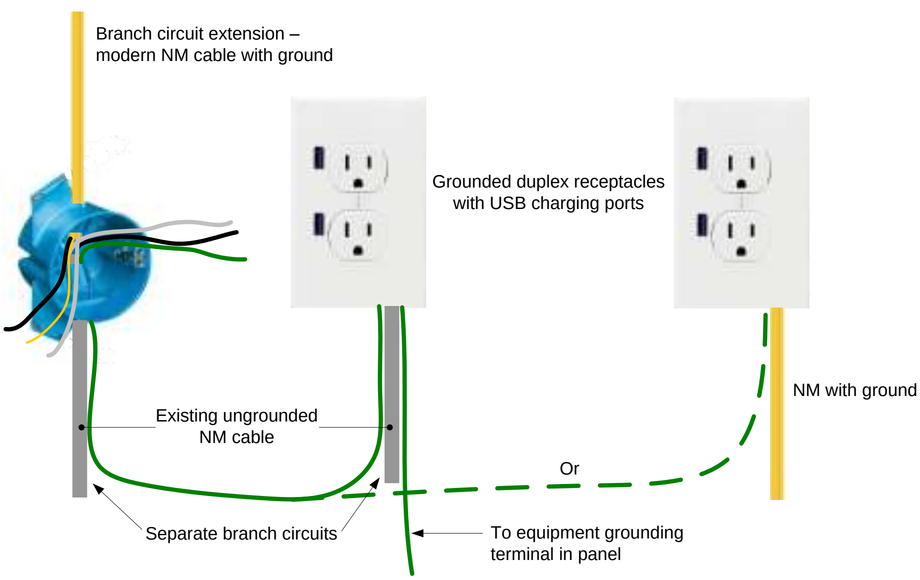
Part VII. Methods of Equipment Grounding – Equipment Grounding Conductor Connections – Nongrounding Receptacle Replacement or Branch Circuit Extensions

Significance

The new Code introduces an additional method for providing an equipment grounding conductor to enhance the safety of older ungrounded wiring.

Analysis

The existing Code lists several methods for providing an equipment grounding conductor (EGC) when extending existing ungrounded circuits or when replacing nongrounding receptacles with grounding-type receptacles. For extending existing ungrounded circuits or replacing non-grounding receptacles, an EGC can be connected to: an accessible point on the grounding electrode system, an accessible point on the grounding electrode conductor, the grounded service conductor within the service equipment enclosure, or the equipment grounding terminal bar in the enclosure where the ungrounded branch circuit originates. The 2014 *NEC* introduces an additional means for providing ungrounded circuits or receptacles with an EGC. The method is illustrated below. The change permits an EGC to be extended/connected from an outlet box on a different circuit that contains an EGC. That outlet box can be supplied with an EGC integral with the circuit wiring (right) or a separate EGC run back to the panel to provide grounding for ungrounded wiring (center).



Summary

An EGC may be extended/connected from an outlet box on a different circuit that contains an EGC. That outlet box can be supplied with an EGC integral with the circuit wiring or a separate EGC run back to the panel to provide grounding for ungrounded wiring.

Application Question: What method of providing a separate EGC for ungrounded wiring provides the lowest impedance for fault current?

Answer: Where the EGC is run in close proximity to the current-carrying conductors of the ct.

Part VIII. Direct-Current Systems – Direct-Current Ground-Fault Detection

Significance

A new section requires ground-fault detection systems for ungrounded dc systems.

Analysis

Dc systems operate either ungrounded or grounded. Grounded systems connect either the positive or negative polarity directly to ground (solidly grounded) or through a resistor to ground. A third type of grounding connects the midpoint, or other point on the system that suits the load, to ground (solidly grounded). Ground-fault detection is typically not used on solidly grounded dc systems. New Section 250.167 requires direct-current ground-fault detection on ungrounded systems and permits detection on grounded systems. Subsection (C) of this new section requires legible, durable marking at the dc source or the first disconnecting means to indicate the grounding type employed. Section 320.3(C)(2) of NFPA 70E-2012, *Standard for Electrical Safety in the Workplace*, lists four types of dc grounding systems. Employing ground-fault equipment in ungrounded dc systems limits fault current to very low values, thus preventing the possibility of fires resulting from high fault currents.

The Bender Model IRDH375 digital ground-fault monitor/ground detector pictured is suitable for use on ungrounded (floating) ac and dc systems. It meets or exceeds the existing requirement in 250.21(B) for ground detectors in ungrounded ac systems and the new requirement in 250.167(A) for detectors in ungrounded dc systems. The IRDH375 monitors for ground faults in ungrounded single-phase ac, three-phase ac, and dc systems by monitoring the system's insulation resistance. It can be connected to systems of up to 793 volts ac and 650 volts dc.

Model IRDH375 ground-fault monitor/ground detector

Courtesy of Bender Inc.

Summary

Ungrounded dc systems shall be equipped with ground-fault detection systems. Grounded dc systems are permitted to have ground-fault detection systems. Dc systems shall be marked at the source or the first disconnecting means to indicate the grounding type employed.

Application Question

Is the dc ground-fault detection requirement in 250.167 applicable to PV systems?

Answer

The requirement is general and similar to the existing requirement for ground detectors for ungrounded ac systems in 250.21. Article 250 applies unless amended by Article 690, PV Systems. Every Code user needs to understand 90.3, Code Arrangement.

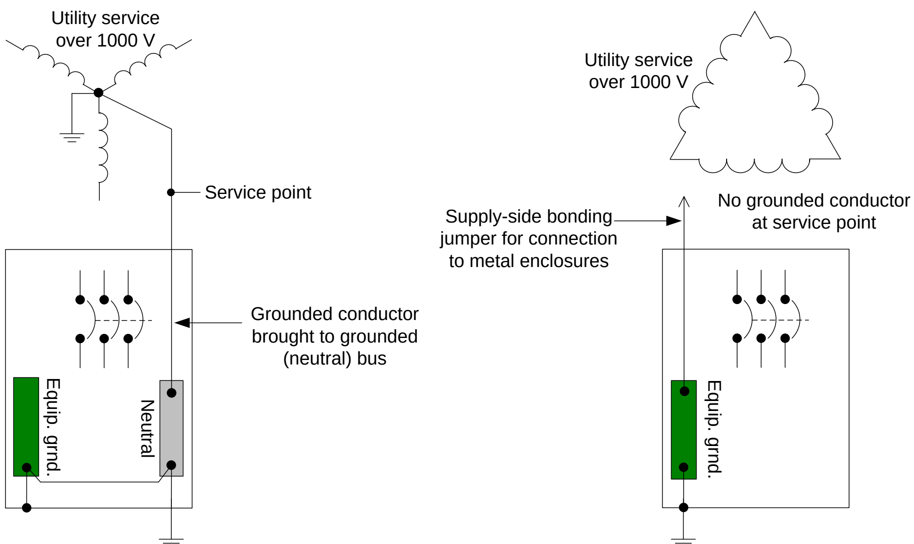
Part X. Grounding of Systems and Circuits of over 1000 Volts – Ground-Fault Circuit Conductor Brought to Service Equipment

Significance

A grounded conductor must be brought to service equipment over 1000 volts for fault clearing.

Analysis

This new section pertaining to over 1000 volts is similar in its requirements to 250.24(C), which requires the grounded conductor of systems 1000 volts or less to be run to the service equipment enclosure(s) for fault clearing purposes. This is true even where the grounded (neutral) conductor is not used for circuits downstream from the service equipment (no neutral loads). Section 250.186 requires the same for systems and circuits over 1000 volts. The intent is to provide a low impedance ground return path back to the source to facilitate operation of overcurrent devices. The *NEC* is applicable only downstream from the service point. Subsection (A) applies to systems where the utility provides a grounded conductor to the service point. Subsection (B) applies where no grounded conductor is available at the service point. Generally, the grounded conductor brought to the service equipment, or the supply-side bonding jumper in subsection (B), is sized according to Table 250.66, but other factors apply including 250.184.



Summary

For utility services over 1000 V, where a grounded conductor is provided at the service point, the grounded conductor shall be brought to the neutral bus in the service disconnect enclosure to provide a low impedance path for fault clearing. Where no grounded conductor is available at the service point, a supply-side bonding jumper shall be used to connect metal enclosures.

Application Question

If the enclosure in the grounded system diagram at the left above becomes accidentally energized, what is the fault return path?

Answer

The path is from the fault (one side of a phase winding) through the *main bonding jumper*, and back to the supply transformer winding through the grounded service conductor.

Part X. Grounding of Systems and Circuits of over 1000 Volts – Grounding and Bonding of Fences and Other Metal Structures

Significance

The 2014 *NEC* contains rules for grounding metal fences and other metal structures at ac substations.

Analysis

Most ac substations are not within the jurisdiction of the *NEC*. However, for installations that are within the scope of the *NEC* (see 90.2), like substations for industrial or institutional complexes or non-utility owned wind generation substations, new rules require grounding and bonding of metal fencing and other metal structures at substations to limit step, touch, and transfer voltages.

Where metal fences are located within 16 ft of exposed electrical conductors or equipment, the fence shall be bonded to the grounding electrode system with wire-type bonding jumpers as follows:

(1) Bonding jumpers shall be installed at each fence corner and at maximum 160 ft intervals along the fence.
(2) Where bare overhead conductors cross the fence, bonding jumpers shall be installed on each side of the crossing.
(3) Gates shall be bonded to the gate support post, which shall be bonded to the grounding electrode system.
(4) Any gate or opening in the fence shall be bonded across the opening by a buried bonding jumper.
(5) The grounding grid or grounding electrode system shall be extended to cover the swing of all gates.
(6) Barbed wire strands above the fence shall be bonded to the grounding electrode system.

Alternative designs performed under engineering supervision are permitted for grounding and bonding of metal fences. Fence grounding is covered in IEEE 80-2000, *IEEE Guide for Safety in AC Substation Grounding*.

Exposed conductive metal structures, including guy wires within 8 ft vertically or 16 ft horizontally of exposed conductors or equipment and subject to contact by persons, shall be bonded to the grounding electrode system(s) in the area. The grounding electrode system shall be in accordance with Part III of Article 250 (see 250.191).

Summary

New Section 250.194 contains prescriptive requirements for grounding metal fencing and other metal structures at ac substations to limit step, touch, and transfer voltages. The provisions are applicable where electrical conductors and equipment are exposed.

This substation serves to connect the wind farm turbines to the utility grid.

Application Question

What size(s) grounding and bonding conductors are required for the grounding and bonding required by this section?

Answer

Per 250.191, the grounding system at ac substations shall be in accordance with Part III of Article 250. The title of Part III of Article 250 is “Grounding Electrode System and Grounding Electrode Conductor.” Part III will provide guidance, but IEEE-80 should also be consulted.

Wiring in Ducts Not Used for Air Handling, Fabricated Ducts for Environmental Air, and Other Spaces for Environmental Air (Plenums) – Other Spaces Used for Environmental Air (Plenums) – Wiring Methods

Significance
Cable ties used with plenum grade cables must also be plenum grade.

Analysis
This new requirement correlates with NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*. NFPA 90A-2012 contains requirements for equipment, including cable ties and other discrete products, in ceiling cavity plenums and raised floor plenums. The requirements include a provision for low smoke and heat release properties in accordance with ANSI/UL 2043, *Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces*. This is now the standard for nonmetallic cable ties and other cable accessories used to secure and support cables in other spaces used for environmental air (plenums). The nonmetallic cable ties and accessories shall be listed as having low smoke and heat release properties. The burgundy cable ties pictured below meet UL 2043 standards. Generally, maroon/burgundy cable ties that have been manufactured over the past several years have been designed to meet this standard. This standard is not the same as that for nonmetallic cables and raceways in air-handling spaces, which must meet flame travel and smoke tests, since their area of exposure is much greater than that of cable fastening devices.

This change has also been made in 770.24, 800.24, 820.24, and 830.24, Mechanical Execution of Work, and in new Section 800.170(C) addressing listing requirements for plenum grade cable ties.

Note also that the title of Article 300 has been changed to better reflect its contents. Added language to the title is underlined in the header of this page. The former title was *Wiring Methods*.

Summary
Nonmetallic cable ties and other nonmetallic cable accessories used for securing and supporting cables installed in air-handling spaces shall be listed as having low smoke and heat release properties.

Application Question
Are communications cables installed in a space used for environmental air subject to this requirement?

Answer
Yes. See 800.24, Mechanical Execution of Work.

Nonmetallic cable ties listed as having low smoke and heat release properties are generally identified by a maroon/burgundy color.

Courtesy of Morris Products Inc.

Code Refresher
- ✓ Chapter 8 (Art. 800, 810, 820, 830, and 840) is a stand-alone chapter and is not subject to the requirements of Chapters 1 through 7 unless specifically referenced in Chapter 8.

Ampacities for Conductors Rated 0-2000 Volts – Tables – Adjustment Factors –
Raceways and Cables Exposed to Sunlight on Rooftops

Significance
An exception for Type XHHW-2 insulated conductors has been added to this subsection.

Analysis
The *NEC* requirement in 310.15(B)(3)(c) is slightly modified from the 2011 version. The title of the subsection now refers to all raceways and cables exposed to sunlight, rather than to circular raceways only. Research performed on several wiring methods since the previous Code cycle concluded that all conductors in all wiring methods experienced significant ambient temperature increases above outdoor temperature when exposed to direct sunlight. Where raceways or cables are exposed to direct sunlight on or above rooftops, the adjustments shown in Table 310.15(B)(3)(c) shall be added to the outdoor temperature to determine the applicable ambient temperature to be used in applying the correction factors in Table 310.15(B)(2)(a) or Table 310.15(B)(2)(b). The adders in Table 310.15(B)(3)(c) have not changed, although there was much discussion about whether or not the adders needed to be increased.

A new exception states that Type XHHW-2 insulated conductors shall not be subject to this ampacity adjustment. The exception recognizes the heat resisting capability of thermoset insulation, which does not soften when exposed to heat. The Informational Notes are more accurately stated in this revision.

The accepted ambient temperature of a conductor is the temperature of the surrounding air. For conductors in conduits the ambient temperature is the temperature of the air inside the conduit. Tests have shown that the temperature of the air inside of conduits lying directly on a dark roof can exceed the outside air temperature by 70°F or more. The temperatures inside conduits on dark-colored roofs are higher than those for light-colored roofs where conduits are on or very near the surface of the roof. Where conduits are about 1 in. or more above the surface of the roof the temperature rise is greater for light-colored roofs because of the reflected heat from light-colored surfaces. Cables and other wiring methods/systems are similarly affected. Despite the differing test results for different wiring methods and roof colors, the ambient temperature adjustment can be adequately addressed by considering the distance of the conduit from the surface of the roof.

For application of this subsection, the outdoor temperature value used must be meaningful. The 2 percentile monthly design dry-bulb temperature is a good indicator of the warm-season temperature. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) *Handbook of Fundamentals*, 2009 edition, contains climatic design information in Chapter 14, which can be referenced concerning design temperatures for various locations. Another source for design temperatures is the Copper Development Association (www.copper.org, search under Applications – Electrical – Building Wire – *Outdoor and Rooftop Temperatures for Selected U.S. and Canadian Locations*). According to their data for ten Maine cities/locations, except for island locations in Maine, the 2% design temperatures range from 80°F to 86°F, depending on the city/area within the state. In reality, these temperatures will be exceeded 2% of the time, e.g., 14.88 hours in the month of July. Nevertheless, the 2% values are generally acceptable values for this purpose. Other data sources may suggest slightly higher design temperatures. The site www.EngineeringToolBox.com (search for "outdoor temperature and relative humidity") lists a design temperature of 90°F for Maine. For Phoenix Arizona, the design temperature listed is 105°F.

Summary

Where raceways or cables are exposed to direct sunlight on or above rooftops, the adjustments shown in Table 310.15(B)(3)(c) shall be added to the outdoor temperature to determine the applicable ambient temperature to be used in applying the correction factors in Table 310.15(B)(2)(a) or Table 310.15(B)(2)(b). Type XHHW-2 insulated conductors shall not be subject to this ampacity adjustment.

Table 310.15(B)(3)(c) Ambient Temperature Adjustment for Raceways or Cables Exposed to Sunlight on or Above Rooftops

Distance Above Roof to Bottom of Raceway or Cable	Temperature Adder	
	°C	°F
On roof 0 – 13 mm (0 – ½ in.)	33	60
Above roof 13 mm – 90 mm (½ in. – 3½ in.)	22	40
Above roof 90 mm – 300 mm (3½ in. – 12 in.)	17	30
Above roof 300 mm – 900 mm (12 in. – 36 in.)	14	25

Example: A 3.5 ton gas/electric central air system is installed on a flat rooftop. The manufacturer specifies the minimum circuit ampacity as 26.8 amps and recommends a breaker size of 40 amps. Supply conductors are run inside 75′ of conduit which is supported by clamps that maintain a distance of ¾″ between the surface of the roof and the bottom of the conduit. Using an outside design temperature of 90°F, what minimum size THHW copper conductors can be used to supply the equipment? (Equipment terminals are rated 75°C.)

Answer: The electric load consists of a motor-compressor and a fan motor. The manufacturer has already applied the requirements in 440.22(B)(1) in determining the recommended circuit breaker size, and 440.33 to arrive at the minimum circuit ampacity for sizing conductors.

110.14(C): The 90°C column in Table 310.15(B)(16) can be used as the starting point for ambient temperature correction; however, the corrected ampacity is not permitted to exceed the 75°C rating of the conductor due to the 75° equipment terminal rating. The adjusted ambient temperature from Table 310.15(B)(3)(c) is 130°F (90 + 40). The ambient temperature correction factor in Table 310.15(B)(2)(a) for the temperature range 123°F-131°F = 0.76. The final adjusted ampacity = 30.4 A (40 x 0.76).

The adjusted ampacity does not exceed the 75°C ampacity (30.4 is less than 35).
Overcurrent protection for 10 AWG copper is permitted to exceed 30 A, since the circuit rating is not the basis for conductor overload protection for this motor-compressor circuit. Section 240.4(D) does not apply to Article 440 (or to several other articles).

<u>A 40-A circuit breaker protecting 10 AWG copper THHW conductors is permitted.</u>

Ampacities for Conductors Rated 0-2000 Volts – 120/240-Volt, Single-Phase Dwelling Services and Feeders

Significance

A familiar table that permits reduced service and feeder conductor sizes for certain residential applications has been deleted.

Analysis

Most Code users are familiar with Table 310.15(B)(7). The first version of this table appeared in the 1978 *NEC*; however, for several preceding Code cycles, notes to ampacity tables and a Simplified Wiring Table permitted reduced conductor sizes for services, feeders, and branch circuits where a low demand factor or diversified load existed. Modern Table 310.15(B)(7) is often used to size service and feeder conductors for residential applications through 400 A. The table is based on a demand of 83% (adjustment factor of 0.83) for certain residential services and feeders. It does not modify the ampacities of conductors as stated in the ampacity tables. Residential electricians know that for certain conductor types they are permitted to use AWG 2 aluminum (4 copper) and AWG 4/0 aluminum (2/0 copper) for 100- and 200-A services respectively. The reduced wire size also applies to feeders, where the feeder conductors carry the entire service load. Without Table 310.15(B)(7), residential service and feeder conductors are required to be AWG 1 aluminum (3 copper) for 100 A and AWG 4/0 aluminum (3/0 copper) for 200 A.

The table has caused confusion and has been misapplied. In some instances, the table has been applied directly without regard to ampacity adjustment and ambient temperature correction that was required for an installation. You can understand the confusion when attempting to derate a conductor’s ampacity from a table that does not list ampacities, but matches service and feeder ratings to conductor sizes.

In the 2014 *NEC*, Table 310.15(B)(7) is deleted and replaced with modified text in Section 310.15(B)(7). As in previous Code editions, the revised section applies to 120/240-volt, single-phase residential services through 400 amperes. It applies to service conductors of single-family dwellings and to service conductors supplying individual units of two-family and multifamily dwellings. Remember that *service conductors* is a broad term. The “service conductors supplying individual units of two-family and multifamily dwellings” is referring to the multiple sets of *service-entrance conductors* permitted by 230.40, Exceptions No. 1 and 2. *Underground service conductors* could also qualify for this size reduction. The section also applies to feeders in these same residential applications, where the feeder carries all of the service current. However, the conductor size reduction does not apply to service conductors that supply two-family or multifamily dwelling buildings, only to service conductors that supply the entire load for an individual dwelling unit within these buildings.

To use Section 310.15(B)(7), simply select the desired service or feeder rating, multiply that rating by 0.83, apply any additional factors required depending on the number of current-carrying conductors and the ambient temperature, then select a conductor with the required ampacity from the appropriate ampacity table. See new Example D7 in Informative Annex D. As in previous editions, the grounded (neutral) conductor is permitted to be sized smaller than the ungrounded conductors, provided the requirements of 220.61 and 230.42 for services and the requirements of 215.2 and 220.61 for feeder conductors are met.

Summary

Table 310.15(B)(7) has been deleted. The reduced conductor size permitted for certain residential services and feeders is still permitted by applying a factor of 0.83 to the rating of the service or feeder. Additionally, any ampacity adjustment (derating) for more than three current-carrying conductors in a raceway or cable, or any ampacity correction for ambient temperature must be applied. If no derating or ambient temperature correction factors are applied, conductors sized according to 310.15(B)(7) will be the same as obtained by use of deleted Table 310.15(B)(7).

Example 1

What size aluminum XHHW service-entrance conductors are required for a 200-A, 120/240-V, single-phase service for a one-family dwelling?

> Service rating = 200 amps.
> Multiply by 0.83: 200 A x 0.83 = 166 A.
> Select an aluminum conductor from the 75°C column in Table 310.15(B)(16).
> Select 4/0 Al XHHW conductors with an ampacity of 180 A, which is at least 166 A.

Example 2

What size aluminum SER cable containing XHHW conductors is required for a 200-A rated feeder that carries all of the service load for a one-family dwelling supplied by a 120/240-V, single-phase service? The feeder cable is embedded in thermal insulation.

> Feeder rating = 200 amps.
> Multiply by 0.83: 200 A x 0.83 = 166 A.
> Section 338.10(B)(4)(a) states that where used in thermal insulation the ampacity shall be in accordance with the conductor's 60°C rating.
> Select an aluminum conductor size from the 60°C column in Table 310.15(B)(16) that has an ampacity of at least 166 amps.
> 250 kcmil aluminum XHHW conductors with a 60°C ampacity of 170 A can be used.

Application Question

A 4-gang meter pack contains 100-A service disconnects for three dwelling units and an owner's panel [common area metering required by 210.25(B)]. What minimum size aluminum SER feeder cables are required to be run to the four panels? The cables are embedded in thermal insulation in the exterior wall where the meter pack is mounted.

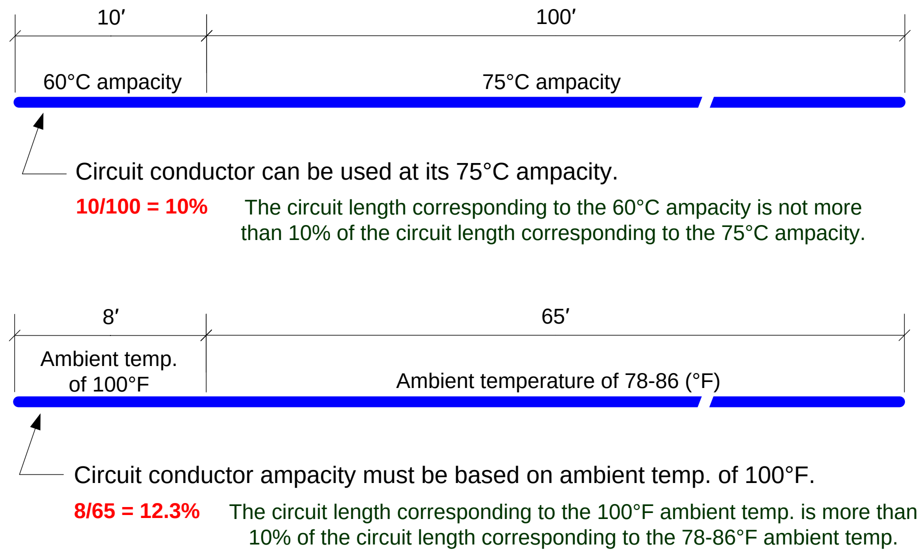
Answer

If the feeders are not embedded in insulation, AWG 2 aluminum can be used (100 A x 0.83 = 83 A → AWG 2 aluminum with a 75°C ampacity of 90 A). If the feeders are embedded in insulation, AWG 1 aluminum can be used, since it's 60°C ampacity of 85 amps is equal to or greater than 83 A. There are two different ampacities that apply to adjacent portions of the same circuit. Generally, the lower ampacity must be used. However, if the cable length within the insulation is not more than 10′ or 10% of the cable length not embedded in insulation, whichever is less, then the 75°C ampacity applies to the overall cable and AWG 2 aluminum is permitted. See Section 310.15(A)(2), Exception and the Code Refresher below.

Code Refresher

- ✓ **Section 310.15(A)(2)**

  This section is used to compute the overall ampacity of circuit conductors, where different ampacities are permitted for adjacent portions of a circuit. The general Code requirement is that the lower ampacity must be used for the entire circuit length. By exception, the higher ampacity can be used if the lower ampacity circuit length is not more than 10′ and not more than 10% of the circuit length of the higher ampacity portion of the circuit. Different ampacities for the same circuit could exist where a portion of a circuit is underground, embedded in thermal insulation, bundled, or exposed to a different ambient temperature. The exception does not apply if conductor ampacity is limited by the rating of terminations, as specified in 110.14(C). See the diagram below for further explanation.



Example Applications of 310.15(A)(2)

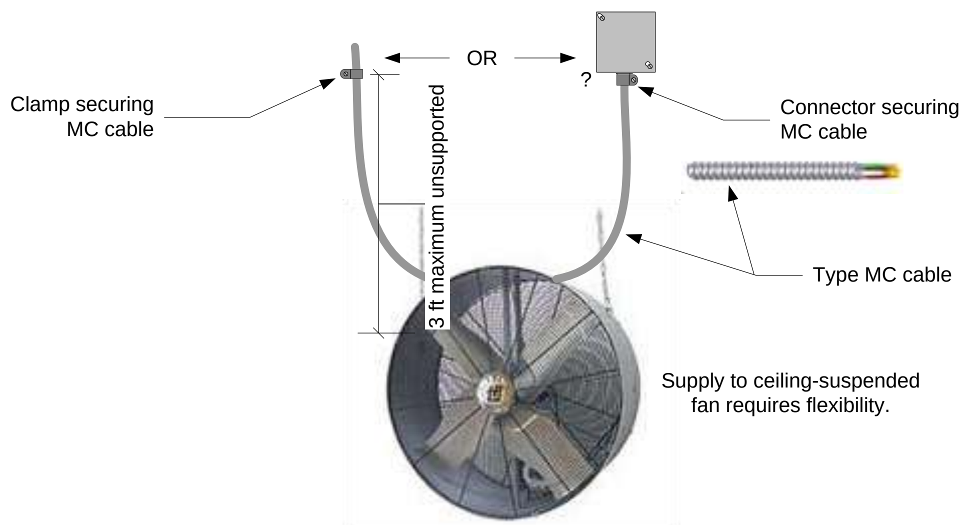
Securing and Supporting – Unsupported Cables

Significance

An additional permission for unsupported Type MC cable is included in the new Code.

Analysis

Unless otherwise provided, Type MC cable shall be secured and supported at intervals not exceeding 6 ft. Cables containing four or fewer conductors size 10 AWG or smaller shall be secured within 12 in. of every box, cabinet, fitting, or other cable termination. MC cable run horizontally in wood or metal framing members, or that has similar supporting means, shall be considered secured and supported. Type MC cable shall be permitted to be unsupported where: (1) the cable is fished in finished buildings and supporting is impractical, or (2) the cable is installed in lengths not exceeding 6 ft from the last cable support to the point of connection to luminaires or other electrical equipment above an accessible ceiling. Subsection (3) is new in the 2014 *NEC* and permits Type MC cable with interlocked armor to be unsupported in lengths up to 3 ft from the last secure support to provide flexibility at equipment. The construction of interlocked armor Type MC makes it suitable for use where flexibility is necessary. The permission applies where flexibility is necessary to minimize the transmission of vibration from equipment or where providing flexibility for equipment that requires movement after installation.



Summary

Type MC cable of the interlocked armor type is permitted to be unsupported in lengths not exceeding 3 ft from the last point where the cable is securely fastened, where used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to facilitate movement of equipment after installation.

Application Question

Does an MC cable connector provide the secure fastening that is required in 330.30(D)(3)?

Answer

In 330.30(D)(2), it states that Type MC cable fittings are permitted as a means of cable *support* for the purpose of this section. New (3) uses the words *securely fastened*. *Supported* and *secured* have different meanings. *Secured* means fastened in place. The AHJ will decide.

Uses Permitted – Branch Circuits or Feeders – Installation Methods for Branch Circuits and Feeders – *Exterior Installations*

Significance

The ampacity of Types USE and USE-2 conductors has been clarified.

Analysis

Types USE (underground service-entrance) and USE-2 cables are designed and listed for underground installations, including direct burial in earth. They are available as single conductors and multiconductor cables. In addition to Types USE and USE-2, some conductors are "triple-rated," such as Type RHH/RHW-2/USE-2 shown below.

Courtesy of Southwire Company

A new exception has been added to 338.10(B)(4)(b), which states that single-conductor Type USE and multi-rated USE conductors are not subject to the ampacity limitations of Part II of Article 340. Section 340.80 limits the ampacity to that of 60°C conductors. Type USE conductors are rated 60°C; Type USE-2 conductors are rated 90°C. It may have been the intent in the existing Code that Types USE and USE-2 conductors were not subject to the 60°C ampacity, but the exception provides clarification.

It is important to remember that Types USE and USE-2 conductors are limited to exterior use, primarily underground. The conductors can be used above ground only as multiconductor, messenger-supported aerial cable or where they emerge from the ground and terminate in outdoor service or metering equipment. Additional usage information can be found in the UL White Book, Category (TYLZ), Service-Entrance Cable. Type USE conductors do not have a flame-retardant covering; hence, the prohibition of their use for interior wiring. The triple-rated conductors are permitted for aboveground use (used as RHW) and interior wiring, since both the RHH and RHW conductor types have flame-retardant coverings.

Summary

Single-conductor Type USE and multi-rated USE conductors are not subject to the ampacity limitations of Part II of Article 340, i.e., the ampacity corresponding to a 60°C temperature rating for the conductor.

Application Question

What is the ampacity of 4/0 AWG aluminum Type USE-2 conductors installed as an underground feeder to supply 120/240-volt, single-phase power to a structure?

Answer

From Table 310.15(B)(16), the 90°C ampacity is 205 amperes. Unless all circuit terminations are rated for 90°C, the 75°C ampacity of 180 amperes must be used. See 110.14(C).

Securing and Supporting – Securely Fastened

Significance

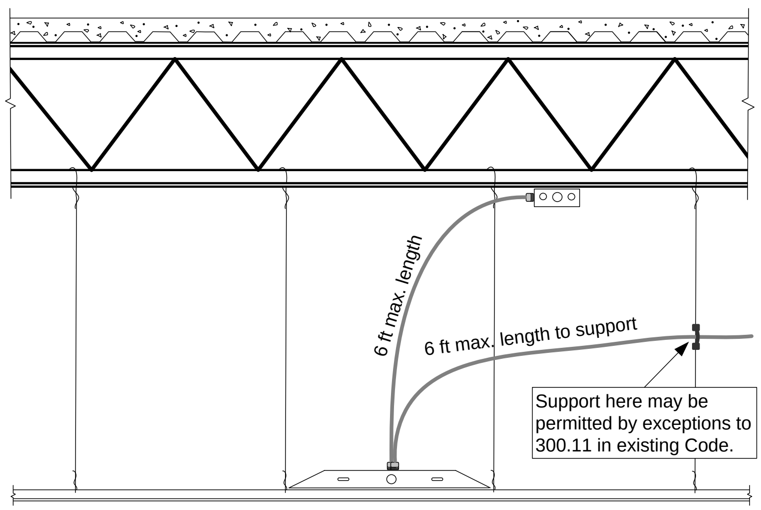
Fittings are a recognized means of support for three flexible raceway types for lengths up to 6 ft.

Analysis

Existing Code permits Types AC [320.30(D)(3)] and MC [330.30(D)(2)] cables to be unsupported within an accessible ceiling to supply luminaires or other electrical equipment. The unsupported cable is limited to 6 ft in length between the last support and the connection to the luminaire or other equipment. For the purpose of these sections, AC and MC cable fittings are permitted as a means of cable support.

The change in the 2014 *NEC* harmonizes with these unsupported cable permissions. The change applies to three raceway types: flexible metal conduit (Type FMC), 348.30(A), Exception No. 4; liquidtight flexible metal conduit (Type LFMC), 350.30(A), Exception No. 4; and liquidtight flexible nonmetallic conduit (Type LFNC-B), 356.30(4). Type LFNC-B is the only type of LFNC permitted in lengths over 6 ft. For the purpose described, the raceway fittings are considered a means of support.

Courtesy of Southwire Company



FMC, LFMC, and LFNC-B fittings are considered a means of support for up to 6 ft lengths of flexible conduit used to supply luminaires or other equipment within accessible ceilings.

Summary

Types FMC, LFMC, and LFNC-B raceways shall be permitted to be unsupported for up to 6 ft in length from the last point of support to the connection to a luminaire or other equipment within an accessible ceiling. For this purpose, the raceway fittings are considered a means of support.

Application Question

For wiring from the J-box to the luminaire in the diagram above, are FMC and LFMC in 6 ft lengths or less permitted to serve as the equipment ground?

Answer

Yes, with conditions, and since flexibility is not required. The flexible conduit must be terminated in listed fittings and overcurrent protection is limited to 20 A. See 250.118(5) and (6).

Part II. Installation – Number of Conductors and Ampacity – Adjustment Factors

Significance
The often misunderstood application of adjustment factors (derating) for over 30 current-carrying conductors in metal wireways has been clarified.

Analysis
Metal wireways installed above panels are a convenient way to transition from horizontally run branch circuits to vertical raceways between the wireways and panels, or for routing circuit cables to a specific panel among a group of panels. Depending on where the branch circuit wiring leaves the wireway relative to where the circuit conductors enter the wireway, the number of current-carrying conductors at a cross section of the wireway could exceed 30 conductors. The 30-conductor threshold does not relate to a total of 30 current-carrying conductors in the wireway, but to 30 current-carrying conductors at any cross section. This is clarified in Section 376.22(B) of the 2014 *NEC*. Where the number of current-carrying conductors at any cross section exceeds 30, the adjustment factors in 310.15(B)(3)(a) must be applied. If 31-40 conductors are installed at any cross section, *all* conductors have to be adjusted to 40% of their initial ampacity, 35% for 41 or more conductors. These are deep reductions in ampacity that apply to all current-carrying conductors, not just to the number of current-carrying conductors over 30.

The raceway entries at the bottom of this wireway (not shown) are such that not more than 30 conductors travel horizontally through any cross section of the wireway. No ampacity reduction is required.

Summary
Where the number of current-carrying conductors *at any cross section* of a metal wireway exceeds 30, the adjustment factors in 310.15(B)(3)(a) must be applied to all current-carrying conductors, not just to the number of current-carrying conductors over 30.

Application Question
Thirty-five current-carrying conductors pass through a cross section of a metal wireway. The conductors are 12 AWG with an insulation rating of 90°C and an ampacity of 30 amps from Table 310.15(B)(16). What is their adjusted ampacity?

Answer
12 A [From Table 310.15(B)(3)(a): 30 amps x 40% = 12 A]

Code Refresher
- ✓ The sum of the cross-sectional areas of all conductors at any cross section of a metal wireway cannot exceed 20% of the interior cross-sectional area of the wireway. [376.22(A)]

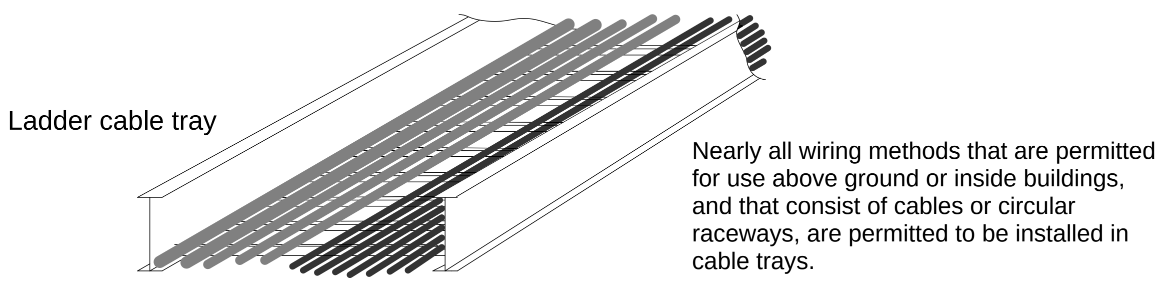
Uses Permitted – Wiring Methods

Significance
Table 392.10(A) has been revised to clarify the wiring methods permitted in cable trays.

Analysis
Nearly all wiring methods that are permitted for use above ground or inside buildings, and that consist of cables or circular raceways, are permitted to be installed in cable trays. The wiring methods permitted in cable tray systems in 392.10(A) are subject to the conditions described in their respective articles and sections. Cable tray is a mechanical support system for service conductors, feeders, branch circuits, communications circuits, control circuits, and signaling circuits. Trays are available in a variety of types and styles to meet various wiring support needs. Trays have become popular cable management systems for data and other low-energy cabling. Wire mesh basket trays are included in the scope of Article 392. Trays are not limited to industrial applications, except that single-conductor cables, welding cables, and medium voltage (Type MV) cables can only be installed in trays in industrial settings.

Where appropriate, this revision has added the wiring Type abbreviation, e.g., Type ITC (instrumentation tray cable), in Table 392.10(A) after the title of the article/wiring method. The wiring methods are listed in the table in alphabetical order. Communications raceways now include optical fiber raceways and signaling raceway.

Table 392.10(A) does not list all of the wiring methods that are permitted in trays. The table contains an entry for "Other factory-assembled, multiconductor control, signal, or power cables that are specifically approved for installation in cable trays."



Summary
Table 392.10(A) has been revised to clarify the wiring methods permitted in cable trays. Where appropriate, the wiring Type abbreviation, e.g., Type ITC (instrumentation tray cable), has been added in Table 392.10(A) after the title of the article/wiring method.

Application Question
Is a cable tray system a raceway-type wiring method?

Answer
Cable tray does not meet the definition of *raceway*. It can be considered a wiring method, but is probably more accurately described as a support system for wiring methods. Note that the title of Chapter 3 is *Wiring Methods and Materials*.

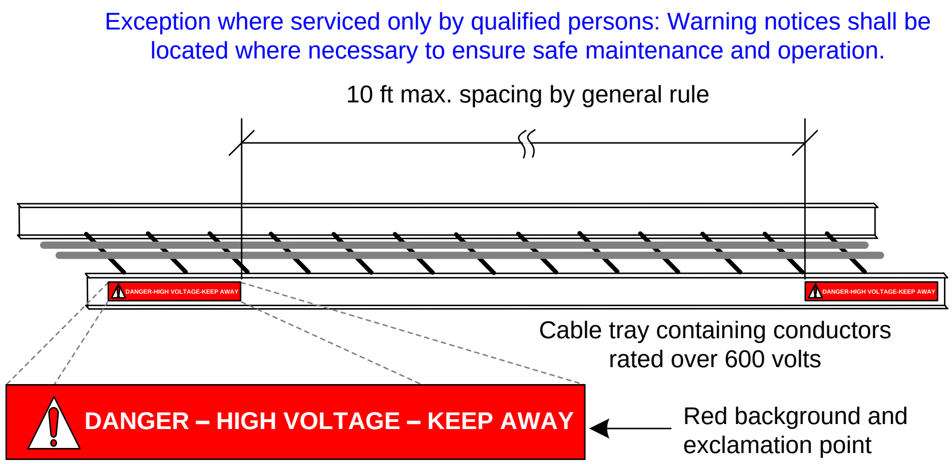
Cable Tray Installation – Marking

Significance
An exception to cable tray marking has been added for industrial establishments.

Analysis
Cable trays containing conductors rated over 600 volts shall be marked with a permanent, legible warning notice with the words "DANGER – HIGH VOLTAGE – KEEP AWAY." The warning shall be placed in readily visible positions along the tray at intervals not exceeding 10 ft. New for this Code, the warning marking(s) or labels shall comply with 110.21(B). Section 110.21(B) is itself a new section in the 2014 *NEC* that contains specific requirements for field-applied hazard markings and labels.

The new exception is for industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons will service the installation. The exception applies to installations of tray that are not accessible (as applied to equipment), and permits the warning notices to be located where necessary to ensure safe maintenance and operation of the installation.

Note that the Over 1000 Volts conversion from Over 600 Volts has not been implemented in this section.



Summary
Cable trays containing conductors rated over 600 volts shall be marked with a permanent, legible warning notice with the words "DANGER – HIGH VOLTAGE – KEEP AWAY." Where the tray is not accessible, in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons will service the installation, warning notices shall be located where necessary to ensure safe maintenance and operation of the installation.

Application Question
What does *accessible* (as applied to equipment) mean?

Answer
Admitting close approach; not guarded by locked doors, elevation, or other effective means.

Low-Voltage Suspended Ceiling Power Distribution Systems

Significance
The increasing availability and use of low-voltage, low-power equipment such as lighting, sensors, information technology equipment, and audio visual equipment necessitates updated rules for installation of low-voltage systems and equipment.

Analysis
With the increasing popularity of alternative energy systems providing dc outputs and the low power needs of energy efficient lighting and other loads, powered ceiling grid offers an innovative wiring method. Many modern devices use dc power at low voltage and current levels. Cell phones, computers, LED luminaires, electronically ballasted fluorescent luminaires, sensors, controls, etc. use dc power at low levels. A ceiling support grid that doubles as a dc distribution system can be efficiently powered from on-site dc generation (PV, wind, fuel cells) without the need for DC to AC to DC conversion costs and power losses. Where the ceiling power distribution grid is supplied by an ac branch circuit, a power server module is used to convert ac to dc (bulk, rather than multiple separate rectifiers) and provides multiple channels for the connection of Class 2 output circuits. Low-voltage suspended ceiling power distribution systems operate at "touch-safe" power levels. Its plug-and-play design permits room or area repurposing and reconfiguration without rewiring.

While the current *NEC* Article 411 limits its coverage to lighting systems operating at 30 volts or less, Article 393 covers lighting and other loads supplied through powered suspended ceiling grid. Many of the requirements for the new article are similar to the requirements in Articles 411 and 725. The low-voltage suspended ceiling power distribution system shall be listed as a complete system or be assembled from only listed parts approved for the function.
Circuits powered by the system shall be limited to 30 volts AC or 60 volts DC and limited to Class 2 power levels in Tables 11(A) and 11(B) in Chapter 9 of the *NEC*.

The power distribution systems are permitted in indoor dry locations for residential, commercial, and industrial installations, and in other spaces used for environmental air in accordance with 300.22(C). They are prohibited in damp or wet locations, classified (hazardous) locations, concealed locations, for lighting in general or critical patient care areas, and where subject to corrosive fumes or vapors or physical damage. Unless specifically listed as part of the assembly, low-voltage suspended ceiling power distribution systems may not be used as part of a fire-rated floor–ceiling or roof–ceiling assembly.

Only the main support rails (defined as *grid bus rail* in the *NEC*) of a suspended ceiling are powered. Power feed connectors connect cables from the power supply to the power distribution busbar, and rail-to-rail connectors interconnect busbars from one ceiling grid rail to another grid rail.

Power supplies shall be protected at a maximum of 20 amperes. Reverse polarity (back feed) protection of DC circuits shall be provided with the power supply, or, where the power supply is not provided as a part of the system, shall be provided as part of the grid rail busbar or as a part of the power feed connector. Generally, Class 2 conductors shall be minimum 18 AWG copper. The Class 2 circuits shall not be grounded. The disconnecting means for the Class 2 power supply shall be accessible and within sight of the Class 2 power source for servicing and maintenance of the power distribution system.

Summary

New Article 393 provides rules for distribution of low voltage current through suspended ceiling grid designed for power distribution for the supply of luminaires, sensors, and other low-power devices and equipment located within, on, or suspended below the ceiling grid. Equipment is supplied by Class 2 circuits using approved cables and connectors.

Application Question

T F The power limitation for an inherently limited Class 2 DC power supply that supplies a single circuit to a dc power distribution grid is 100 VA.

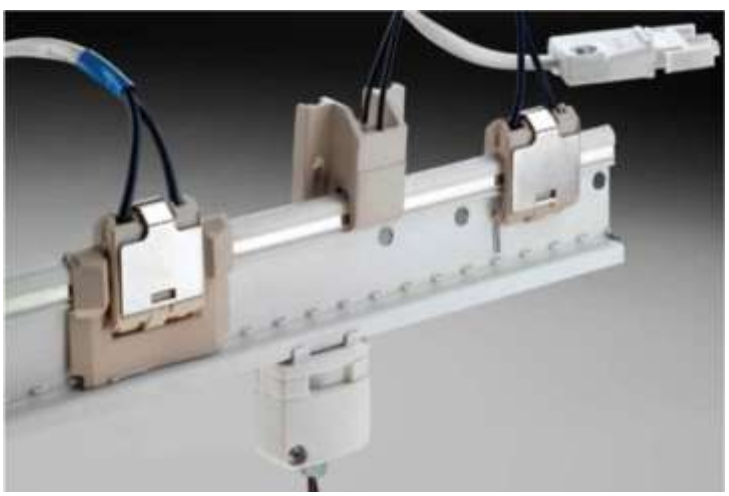
Answer

True. See Table 11(B) in Chapter 9 of the *NEC*.

Power server module mounted above ceiling grid

16-channel power module with Class 2 output circuits

Courtesy of Nextek Power Systems



Cable connectors connecting to dc power grid

Courtesy of Tyco Electronics Corporation, a TE Connectivity Ltd. company

Switch Connections – Switches Controlling Lighting Loads

Significance

Five more exceptions have been added to the rule for providing a neutral conductor at a switch used for the control of lighting.

Analysis

This rule was introduced in the 2011 *NEC* and requires that the grounded circuit conductor of a general-purpose circuit that supplies lighting be provided at switch locations for the future connection of electronic lighting controls such as occupancy sensors. This action was designed to halt the use of equipment grounding conductors being used as current-carrying conductors for electronic lighting controls. The Code change addresses those instances where an occupancy sensor or other electronic lighting control would be redundant, excessive, or impossible to install. There are seven conditions in which the grounded conductor is not required to be provided:

(1) [2011] Where conductors enter the box enclosing a switch through a raceway, provided the raceway is large enough to include a grounded conductor

(2) [2011] Where the box enclosing the switch is accessible for the installation of an additional or replacement cable without removing finish materials

(3) [2014] Where snap switches with integral enclosures comply with 300.15(E) – e.g., boxless switches in 334.40(B) and in manufactured homes

(4) [2014] Where a switch does not serve a habitable room or bathroom – e.g., closets (wall switches and door-jamb switches), hallways, storage and utility spaces, garages, etc. – Habitable rooms are rooms for living, sleeping, eating, or cooking.

(5) [2014] Where multiple switch locations control the same lighting load such that the entire floor area of a room is "seen" from a single location or combined switch locations – It may be that more than one sensor is needed to "see" the entire room or space.

(6) [2014] Where lighting in the area is controlled by automatic means

(7) [2014] Where a switch controls a receptacle load – unknown load – listing of sensor will not include a receptacle load – See 210.70(A)(1), Exc. 1.

Summary

The grounded circuit conductor of a general-purpose circuit that supplies lighting shall be provided at switch locations for the future connection of electronic lighting controls such as occupancy sensors. There are seven conditions where the rule does not apply—where an occupancy sensor or other electronic lighting control would be redundant, excessive, or impossible to install.

Application Question

Does the requirement apply to switch locations not in the illuminated area? Outdoor areas?

Answer

Code panel members agreed that switch locations not in the illuminated area should have a grounded connection to accommodate some dimmers. It does not appear that the rule applies to switches for outdoor lighting outlets (habitable area?). A level of illumination is required at entrances and exits. See 210.70(A)(2)(b) for required lighting at dwelling unit entrances or exits.

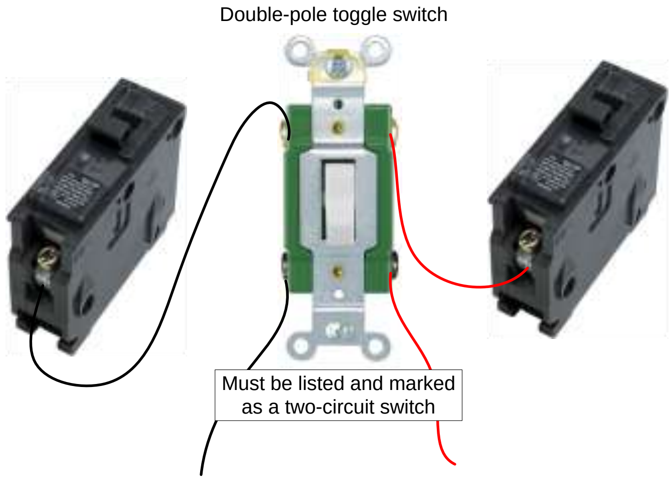
Accessibility and Grouping – Multipole Snap Switches

Significance

The permission for multipole switches to switch more than a single circuit is now more restrictive.

Analysis

In previous Codes a multipole, general-use snap switch was permitted to control more than one circuit if the voltage rating of the switch was not less than the nominal line-to-line voltage of the system supplying the circuits. Alternatively, the switch was permitted to control more than one circuit if the switch was listed and marked as a two-circuit or three-circuit switch. The latter permission has been brought forward to the 2014 *NEC*, but the former has been deleted. This is consistent with the *UL Guide Information for Electrical Equipment* (the White Book), which states that "Multi-pole, general-use snap switches have not been investigated for more than single-circuit operation unless marked '2-circuit' or '3-circuit.'" A line-to-line circuit, such as a 240-volt circuit supplying a 240-volt load, is a single circuit, but a multiwire circuit is not a single circuit.



Summary

A multipole, general-use snap switch cannot be fed from (used to control) more than a single circuit unless the switch is listed and marked as a two-circuit or three-circuit switch.

Application Question

If the switch in the diagram above is listed and marked as a two-circuit switch and used as such, serving single-phase line-to-neutral loads, how will the circuit breakers need to be arranged in the panel? Is this a multiwire branch circuit?

Answer

The breakers will have to be vertically adjacent and tied with an identified handle tie, or a 2-pole breaker could be used. This is to satisfy 210.7. A multiwire branch circuit has one neutral.

Code Refresher

- ✓ 210.7 – Where two or more branch circuits supply devices or equipment on the same mounting strap, a means to simultaneously disconnect the ungrounded conductors supplying these devices shall be provided at the point of origin of the branch circuits.

Receptacle Rating and Type – Controlled Receptacle Marking

Significance

This new section requires specific marking on receptacles that are energized and de-energized automatically in conjunction with energy management or building automation.

Analysis

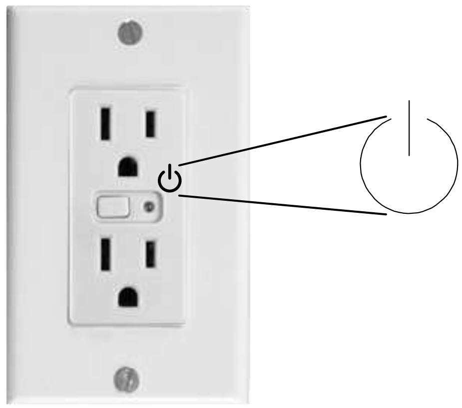
Energy standards currently address building envelope requirements and mechanical equipment efficiencies such as HVAC (heating ,ventilating, and air conditioning) systems. Standards for lighting power densities, occupant-sensing controls, daylighting requirements, and equipment like variable speed fans, etc. have been successfully used to reduce energy consumption. ASHRAE 90.1-2010, *Energy Standard for Buildings, Except Low-Rise Residential Buildings*, is the basis for the International Energy Conservation Code. This popular ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) standard establishes a baseline for the Leadership in Energy and Environmental Design (LEED) program. Section 8.4.2 of ASHRAE 90.1-2010 requires that at least 50% of 125-volt, 15- and 20-amp receptacles installed in private offices, open offices (including those installed in modular partitions), and computer classrooms be automatically controlled. The control can be by time-of-day systems, occupancy control, or other automatic control based on occupancy. This load is commonly referred to as "plug load." The rule does not apply to dwelling occupancies that are not more than three stories above grade.

New Section 410.3(E) of the *NEC* requires that all nonlocking-type 125-volt, 15- and 20-amp receptacles that are controlled by an automatic control device, or incorporate control features that de-energize the outlet for the purpose of energy management or building automation, be marked to indicate that they are a controlled receptacle. They shall be marked with the symbol shown below. The marking shall be visible after installation. The marking is not required for receptacles controlled by a wall switch as permitted by 210.70 to provide the required room lighting outlets. The Code allows for either manufacturer marking or a field marking that is acceptable to the authority having jurisdiction (AHJ).

There are receptacles currently on the market that operate on "Z-Wave" technology (automatically controlled). The receptacle shown below is one such receptacle. At least one of the receptacle brands currently available is marked to indicate that it is a controlled receptacle. However, the marking does not conform to the specifics of this new *NEC* requirement.

Summary

Nonlocking-type 125-volt, 15- and 20-amp receptacles that are controlled by an automatic control device, or incorporate control features that de-energize the outlet for the purpose of energy management or building automation, shall be marked by the prescribed symbol. The marking is not required for receptacles controlled by a wall switch as permitted by 210.70 to provide the required room lighting outlets.



Automatically controlled receptacle indicated by symbol on receptacle face

Application Question

T F The symbol that is required to be placed on automatically controlled receptacles is permitted to be on the faceplate.

Answer

False. The symbol must be on the receptacle face such that it is visible after installation. For split-wired receptacles, it should be clear which receptacle is automatically controlled. For a typical duplex receptacle (not decora style), it may be difficult to locate the symbol such that it can be seen while an attachment plug is inserted. It is not clear if the "visible after installation" requirement means visible after a plug is inserted.

Code Refresher/Revision

- ✓ **406.3(D)** Isolated ground receptacles shall be identified by an **orange triangle** located on the face of the receptacle. In addition to the marking, some isolated ground receptacles are orange.

- ✓ **517.18(B)** (and other sections) "Hospital grade" receptacles are identified by a **green dot** on the face of the receptacle. Although the Code does not address specifics of the identification, the green dot is specified in the UL listing. The phrase "Hospital Grade" or "Hosp. Grade" are marked on the back of qualifying receptacles ("Hospital Only" for 20-A, 125-V locking receptacles with no green dot).

- ✓ **517.30(E)** The cover plates for receptacles or the receptacles themselves supplied from the essential electrical system shall have a distinctive color or marking so as to be readily identifiable. The color **red** is commonly used as the identifier.

Code Revision: 517.41(E) Receptacle Identification The 2014 *NEC* requires nonlocking-type, 125-volt, 15- and 20-ampere receptacles supplied from the essential electrical system to have an illuminated face or an indicator light to indicate there is power to the receptacle. This applies to nursing homes and limited care facilities. There is no similar change in 517.30(E) for hospitals.

General Installation Requirements – Replacements – Arc-Fault Circuit-Interrupter Protection

Significance

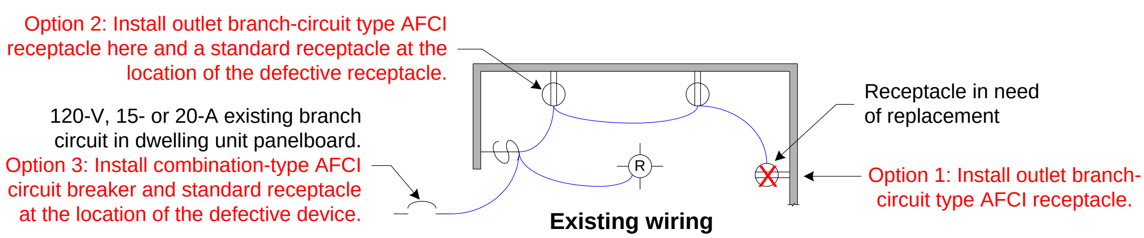
This very important requirement was introduced in the 2011 *NEC* as a new subsection, with an effective date of January 1, 2014.

Analysis

Since this rule becomes effective with adoption of the 2014 *NEC*, it is beneficial to review this section anew. The rule is similar to the rule requiring GFCI-protected receptacles to be installed where replacements are made at receptacle outlets that are required to be GFCI-protected elsewhere in the Code. Where a receptacle outlet is supplied by a branch circuit that requires arc-fault circuit-interrupter protection elsewhere in the Code, a replacement receptacle at this outlet shall be one of the following:

1) A listed outlet branch-circuit type AFCI receptacle,
2) A receptacle protected by a listed outlet branch-circuit type AFCI receptacle, or
3) A receptacle protected by a listed combination-type AFCI circuit breaker.

The options permit the use of AFCI circuit breakers or AFCI receptacles. This requirement is related to, but should not be confused with, 210.12(B), Branch Circuit Extensions or Modifications – Dwelling Units. Section 210.12(B) has an effective date of January 1, 2011, or whenever the 2011 *NEC* is adopted, and requires AFCI protection for specific branch circuits that are modified, extended, or replaced in existing dwellings. Section 406.4(D)(4) requires AFCI-protected replacement receptacles for circuits in existing dwellings that require AFCI protection.



Summary

Where existing wiring supplies a receptacle from a branch circuit that requires arc-fault circuit-interrupter protection by new *NEC* rules, a replacement receptacle at this outlet shall be a listed outlet branch-circuit type AFCI receptacle, a receptacle protected by a listed outlet branch-circuit type AFCI receptacle, or a receptacle protected by a listed combination-type AFCI circuit breaker.

Application Question

What rooms and occupancy type(s) does this requirement for replacing a defective receptacle with an AFCI-protected receptacle apply to?

Answer

When replacing a receptacle located in any of the rooms or areas that require AFCI protection for branch circuits supplying the room or area, AFCI protection for the receptacle shall be provided. The rule applies to dwelling units and dormitories.

Receptacles in Damp or Wet Locations – Wet Locations – Receptacles of 15 and 20 Amperes in a Wet Location

Significance

The requirement for "extra-duty" outlet box hoods has been broadened in its application.

Analysis

There have been many failures of in-use covers. The hinges for some types of covers are not durable, sometimes leaving the receptacle uncovered. The so-called "extra-duty" cover/hood was introduced in the 2011 *NEC* and was required for receptacles installed in wet locations on enclosures supported from grade at other than one- or two-family dwellings. The 2014 *NEC* requires these extra-duty covers on all 15- and 20-ampere, 125- through 250-volt receptacles installed in wet locations. Hoods installed for this purpose shall be listed and identified as "extra-duty." Section 590.4(D)(2) applies the same new requirement to temporary installations.

The more durable hoods will be beneficial for harsh work environments such as outdoor receptacles at construction sites and will help to alleviate the problem of broken in-use covers in all applications and occupancy types.

It may be difficult to identify an extra-duty hood. Generally, they are constructed of metal. Requirements for extra-duty outlet box hoods are found in ANSI/UL 514D-2000, *Cover Plates for Flush-Mounted Wiring Devices*.

Red·Dot® Code Keeper® Universal While-In-Use Cover

Thomas & Betts Corp.

Summary

Extra-duty hoods are required on all 15- and 20-ampere, 125- through 250-volt receptacles installed in wet locations.

Application Question

What is a *wet location*?

Answer

For the purpose of this section, a wet location is an unprotected location exposed to weather. Since the receptacle is exposed to weather, the receptacle must be *weatherproof*, constructed or protected so that exposure to the weather will not interfere with successful operation.

Dimmer-Controlled Receptacles

Significance

This change permits, with limitations, the use of dimmers for the control of receptacles used for lighting.

Analysis

Section 404.14(E) permits general-use dimmer switches to be used only to control permanently installed incandescent luminaires unless listed for the control of other loads and installed accordingly. Dimmers have been misapplied for control of low-voltage, under-cabinet lighting and other cord-and-plug-connected lighting to achieve desired lighting levels or ambience. New Section 406.15 permits dimmer control of receptacles used for lighting purposes, so long as the plug/receptacle combination is a nonstandard configuration type that is specifically listed and identified for each such unique combination. One such nonstandard configuration is pictured below. The duplex receptacle marked "CAUTION LAMP LOADS ONLY" will not accept plugs that are not intended to be used with this receptacle. The plug shown is listed for this combination.

Summary

Dimmer control of receptacles used for lighting purposes is permissible, so long as the plug/receptacle combination is a nonstandard configuration type that is specifically listed and identified for each such unique combination.

Application Question

Is the receptacle pictured above a 15-A or a 20-A receptacle?

Answer

The protrusion between the receptacle slots is not all that's nonstandard. The neutral T-slot appears the same as that of a 20-A receptacle, but the slot on the "hot" side is shorter than that of a typical receptacle. Note the nonstandard blade width on the plug. Actually, it is a 20-A, Lutron Nova T receptacle, model #NTR-20-DFDU-IV.

Part IV. Construction Specifications – Wire-Bending Space Within an Enclosure Containing a Panelboard – Back Wire-Bending Space

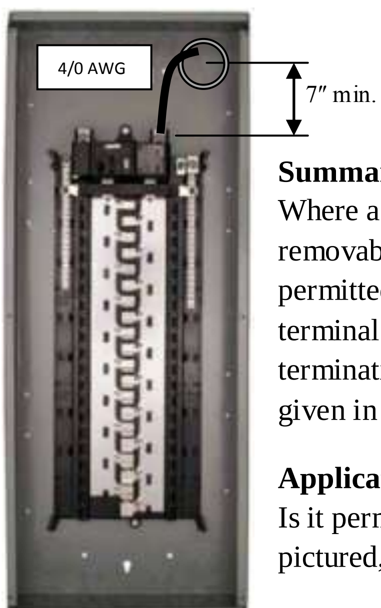
Significance

The new Code addresses wire-bending space for conductors entering the back of an enclosure.

Analysis

Existing requirements for wire-bending space at the top, bottom, and sides of panelboard enclosures are specified in Tables 312.6(A) and (B). Top and bottom wire-bending space is described in Table 312.6(B), with exceptions, and side wire-bending space is described in Table 312.6(A). These rules in 408.55 have been reorganized in subsections (A) and (B) in the 2014 *NEC*. In the new rules in subsection (C), where a raceway or cable entry is in the wall of an enclosure opposite a removable cover, the depth of the enclosure (distance from the wall to the cover) shall be permitted to be the distance required in Table 312.6(A) for one wire per terminal. In the panelboard below, for a 4/0 AWG conductor entry in the back wall of the panel, the enclosure is required to be a minimum of 4 in. deep. This is the approximate depth of many residential loadcenters. Also, the distance from the center of the rear entry to the nearest termination for the entering conductors shall not be less than the distance required in Table 312.6(B). From that table, the distance from the center of the cable or raceway entry (for a 4/0 AWG conductor, other than compact Alum.) to the nearest termination for the entering conductors shall not be less than 7 in.

Existing Section 312.6 contains requirements for minimum width of wiring gutters and minimum wire-bending space at terminals for conductors entering or leaving cabinets, cutout boxes, and meter socket enclosures. *Panelboards* are placed in *cabinets* or *cutout boxes* (enclosures).



Summary

Where a raceway or cable entry is in the wall of an enclosure opposite a removable cover, the distance from that enclosure wall to the cover shall be permitted to be the distance required in Table 312.6(A) for one wire per terminal. Also, the distance from the center of the rear entry to the nearest termination for the entering conductors shall not be less than the distance given in Table 312.6(B).

Application Question

Is it permissible for a 4/0 Al SEU cable to enter the rear of the panelboard pictured, on either side of, and adjacent to, the panelboard frame?

Answer

From Table 312.6(A), for one 4/0 conductor per terminal, the minimum depth required for the panel is 4 in. From Table 312.6(B), the minimum wire-bending space required is 7 in. Since the gutter is narrow, the 4/0 conductors would have to run vertically up or down inside the panel a distance of 7 in. after entering the panel before bending to terminate on a circuit breaker.

Tire Inflation and Automotive Vacuum Machines

Significance

Not all ground-fault circuit-interrupter (GFCI) requirements are located in Article 210. This expansion of GFCI requirements is in Article 422 and applies to specific appliances.

Analysis

GFCI protection for personnel (5 mA) is required by the 2014 Code for tire inflation and automotive vacuum machines provided for public use. Much of this equipment is hard-wired and will be protected by GFCI circuit breakers, but GFCI receptacle protection is permitted. Where this equipment is outdoors and is cord-and-plug connected, this is not a Code change, since outdoor convenience receptacles in public spaces have been required to be GFCI protected since the 2005 *NEC*. Most of this equipment is located outdoors subject to the elements and used by persons standing on conductive, sometimes wet, surfaces. Deteriorated electrical equipment expected to experience severe use is a good reason for requiring life-saving GFCI protection. All tire inflation equipment, but only automotive vacuum machines, are covered by this requirement.

Tire inflation and automotive vacuum equipment

Summary

The electrical supply for tire inflation equipment and automotive vacuum machines provided for public use shall have GFCI protection for personnel.

Application Question

T F Only tire inflation equipment and automotive vacuum machines supplied by 120-volt, 15- and 20-amp circuits are required to be GFCI protected.

Answer

False. The GFCI requirement is broadly stated and applies to any voltage and current rating, and to both receptacle-supplied and hard-wired (protected by a GFCI circuit breaker) equipment.

Part VI. Duct Heaters – Installation – General – Limited Access

Significance

Specific requirements have been added for access to, and working space about, electric duct heaters installed in a space above a ceiling.

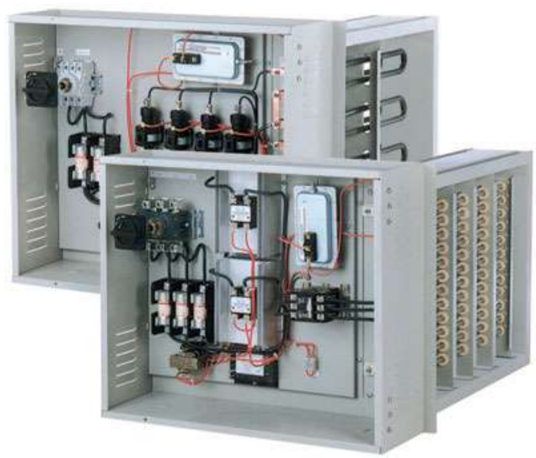
Analysis

Existing Code requires access to duct heaters and sufficient clearance to permit replacement of controls and heating elements and for adjusting and cleaning. Existing Code also states in the last sentence in 424.66: "See 110.26." This is not mandatory language requiring compliance with the working space rules in 110.26.

Working space about electrical enclosures for resistance heating element-type duct heaters that are mounted on duct systems and contain equipment that requires adjustment, servicing, or maintenance while energized shall comply with the requirements of new subsection (B), Limited Access. Where the heating enclosure is located in a space above a ceiling, the following rules apply:

(1) The enclosure shall be accessible through a lay-in type ceiling or an access panel(s).
(2) The width of the working space shall be the width of the enclosure or a minimum of 30 in., whichever is greater.
(3) All doors or hinged panels shall open to at least 90 degrees.
(4) The space in front of the enclosure shall comply with the depth requirements in Table 110.26(A)(1). Ceiling grid T-bar shall be permitted in this space.

This will result in a much safer work zone for service personnel working on ladders and around grounded metal objects above a suspended ceiling—metal building structure, metal piping, etc.



Electric duct heaters

Courtesy of Rapid Cool

Summary

Installations of electric heaters in ducts above accessible ceilings shall have a working space width the greater of 30 in. or the width of the equipment, shall permit hinged panels to open at least 90°, and shall have a front working space depth in accordance with Table 110.26(A)(1).

Application Question

What is the depth of the front working space required by 424.66(B) for a 480-volt duct heater? (Assume no grounded parts opposite the heater.)

Answer

From Table 110.26(A)(1): For the nominal voltage to ground range of 151–600 volts and Condition 1(no live or grounded parts on the other side of the working space), the required depth of the working space is 3 ft.

