CHAPTER

3 WIRING METHODS AND MATERIALS

INTRODUCTION TO CHAPTER 3—WIRING METHODS AND MATERIALS

Chapter 2 provided the general rules for wiring and protection of conductors, and was primarily concerned with the correct sizing of circuits and the means of protecting them. This differs from the purpose of Chapter 3, which is to correctly install the conductors that make up those circuits.

Chapter 2 was a bit of an uphill climb, because many rules had a kind of abstract quality to them. Chapter 3, on the other hand, gets very specific about conductors, cables, boxes, raceways, and fittings. It's also highly detailed about the installation and restrictions involved with wiring methods.

It's because of that detail that many people incorrectly apply the Chapter 3 wiring methods rules. Be sure to pay careful attention to the details, rather than making the mistake of glossing over something. This is especially true when it comes to applying the Tables.

The type of wiring method you'll use depends on several factors: *Code* requirements, the environment, need, and cost are among them.

Power quality is a major concern today. The cost of poor power quality runs into the millions of dollars each month in the United States alone. Grounding and bonding deficiencies (refer back to Article 250) constitute the number one cause of power quality problems. Violations of the Chapter 3 wiring methods rules constitute the number two cause of power quality problems. *Code* violations can also lead to fire, shock, and other hazards. This is particularly true of Chapter 3 violations.

Chapter 3 is really a modular assembly of articles, each detailing a specific area of an electrical installation. It starts with wiring methods [Article 300], covers conductors [Article 310], and then enclosures [Articles 312 and 314]. The next series [Articles 320 through 340] addresses specific types of cables, with Articles 342 through 390 covering specific types of raceways. We close with Article 392, a support system, and the last string [Articles 394 through 398] for open wiring.

Notice as you read through the various wiring methods that, for the most part, the section numbering remains the same in each article. This makes it very easy to locate specific requirements in a particular article. For example, the rules for securing and supporting can be found in 3xx.30 of each article. In addition to this, you'll find a "uses permitted" and "uses not permitted" section in nearly every article.

Wiring Method Articles

- **Article 300.** Wiring Methods. Article 300 contains the general requirements for all wiring methods included in the *NEC*, except for signaling and communications systems, which are covered in Chapters 7 and 8.

- **Article 310.** Conductors for General Wiring. This article contains the general requirements for conductors, such as insulation markings, ampacity ratings, and conductor use. Article 310 doesn't apply to conductors that are part of flexible cords, fixture wires, or conductors that are an integral part of equipment [90.6 and 300.1(B)].

- **Article 312.** Cabinets, Cutout Boxes, and Meter Socket Enclosures. Article 312 covers the installation and construction specifications for cabinets, cutout boxes, and meter socket enclosures.

- **Article 314.** Outlet, Device, Pull and Junction Boxes, Conduit Bodies, Fittings, and Handhole Enclosures. Installation requirements for outlet boxes, pull and junction boxes, as well as conduit bodies, and handhole enclosures are contained in this article.

Cable Articles

- **Article 320.** Armored Cable (Type AC). Armored cable is an assembly of insulated conductors, 14 AWG through 1 AWG, individually wrapped with waxed paper. The conductors are contained within a flexible spiral metal (steel or aluminum) sheath that interlocks at the edges. Armored cable looks like flexible metal conduit. Many electricians call this metal cable BX®.

- **Article 330.** Metal-Clad Cable (Type MC). Metal-clad cable encloses insulated conductors in a metal sheath of either corrugated or smooth copper or aluminum tubing, or spiral interlocked steel or aluminum. The physical characteristics of Type MC cable make it a versatile wiring method permitted in almost any location and for almost any application. The most commonly used Type MC cable is the interlocking type, which looks similar to armored cable or flexible metal conduit.

- **Article 334.** Nonmetallic-Sheathed Cable (Type NM). Nonmetallic-sheathed cable encloses two, three, or four insulated conductors, 14 AWG through 2 AWG, within a nonmetallic outer jacket. Because this cable is nonmetallic, it contains a separate equipment grounding conductor. Nonmetallic-sheathed cable is a common wiring method used for residential and commercial branch circuits. Many electricians call this plastic cable Romex®.

- **Article 338.** Service-Entrance Cable (Types SE and USE). Service-entrance cable can be a single-conductor or a multiconductor assembly within an overall nonmetallic covering. This cable is used primarily for services not over 600V, but is also permitted for feeders and branch circuits.

Raceway Articles

- **Article 362.** Electrical Nonmetallic Tubing (ENT). Electrical nonmetallic tubing is a pliable, corrugated, circular raceway made of PVC. It's often called "Smurf Pipe" or "Smurf Tube," because it was available only in blue when it originally came out at the time the children's cartoon characters "The Smurfs," were most popular.

- **Article 376.** Metal Wireways. This article covers the use, installation, and construction specifications for metal wireways and associated fittings. A metal wireway is a sheet metal trough with hinged or removable covers for housing and protecting electric conductors and cable, in which conductors are placed after the wireway has been installed as a complete system.

ARTICLE

300 Wiring Methods

INTRODUCTION TO ARTICLE 300—WIRING METHODS

Article 300 contains the general requirements for all wiring methods included in the *NEC*. However, this article doesn't apply to communications systems, which is covered in Chapter 8, except when Article 300 is specifically referenced in Chapter 8.

This article is primarily concerned with how to install, route, splice, protect, and secure conductors and raceways. How well you conform to the requirements of Article 300 will generally be evident in the finished work, because many of the requirements tend to determine the appearance of the installation.

Because of this, it's often easy to spot Article 300 problems if you're looking for *Code* violations. For example, you can easily see when someone runs an equipment grounding conductor outside a raceway instead of grouping all conductors of a circuit together, as required by 300.3(B).

This is just one of the common points of confusion your studies here will clear up for you. To help achieve that end, be sure to carefully consider the accompanying illustrations, and also refer to Article 100 as needed.

61 300.3 Conductors.

(A) Conductors. Conductors must be installed within a Chapter 3 wiring method, such as a raceway, cable, or enclosure.

Exception: Overhead conductors can be installed in accordance with 225.6.

(B) Circuit Conductors Grouped Together. All conductors of a circuit must be installed in the same raceway, cable, trench, cord, or cable tray, except as permitted by (1) through (4). Figure 300–1

> **Author's Comment:** All conductors of a circuit must be installed in the same raceway, cable, trench, cord, or cable tray to minimize induction heating of ferrous metal raceways and enclosures, and to maintain a low-impedance ground-fault current path [250.4(A)(3)].

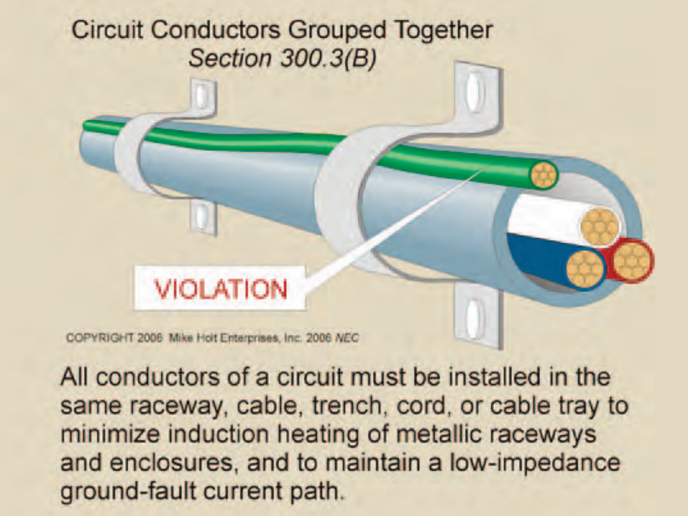

Figure 300–1

(1) Paralleled Installations. Conductors can be run in parallel, in accordance with 310.4, and must have all circuit conductors within the same raceway, cable tray, trench, or cable. Figure 300–2

Exception: Parallel conductors run underground can be run in different raceways (Phase A in raceway 1, Phase B in raceway 2, etc.) if, in order to reduce or eliminate inductive heating, the raceway is nonmetallic or nonmagnetic and the installation complies with 300.20(B). See 300.3(B)(3) and 300.5(I) Ex 2.

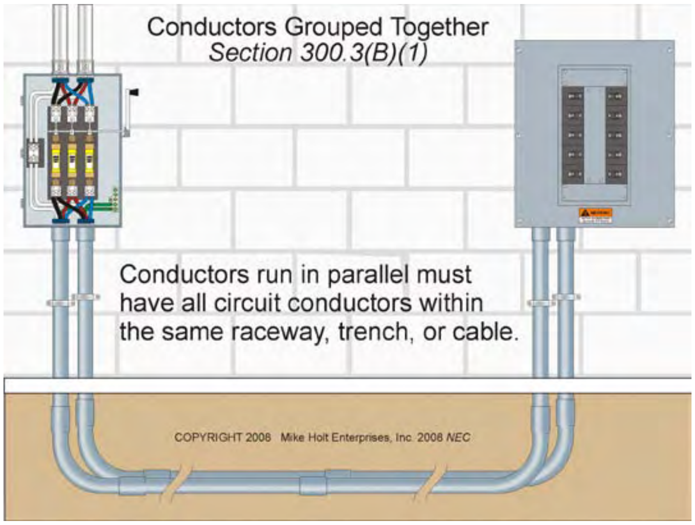

Figure 300–2

(2) Grounding and Bonding Conductors. Equipment grounding conductors can be installed outside of a raceway or cable assembly for certain existing installations. See 250.130(C). Equipment grounding jumpers can be located outside of a flexible raceway if the bonding jumper is installed in accordance with 250.102(E). Figure 300–3

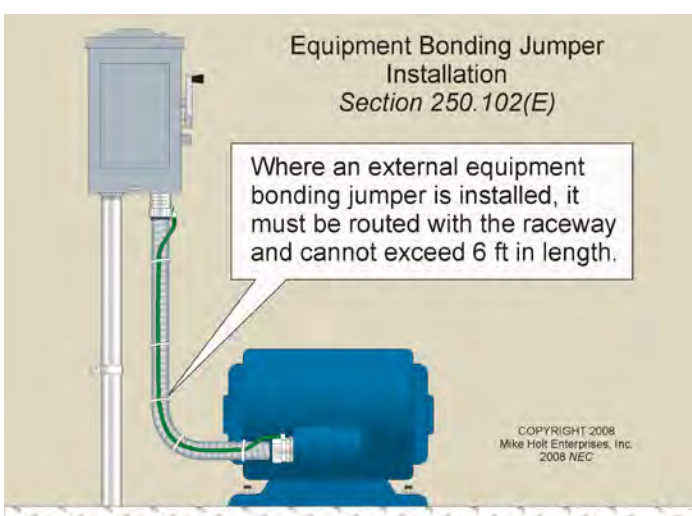

Figure 300–3

(3) Nonferrous Wiring Methods. Circuit conductors can be run in different raceways (Phase A in raceway 1, Phase B in raceway 2, etc.) if, in order to reduce or eliminate inductive heating, the raceway is nonmetallic or nonmagnetic and the installation complies with 300.20(B). See 300.3(B)(1) and 300.5(I) Ex 2.

(C) Conductors of Different Systems.

(1) Mixing. Power conductors of ac and dc systems rated 600V or less can occupy the same raceway, cable, or enclosure if all conductors have an insulation voltage rating not less than the maximum circuit voltage. Figure 300–4

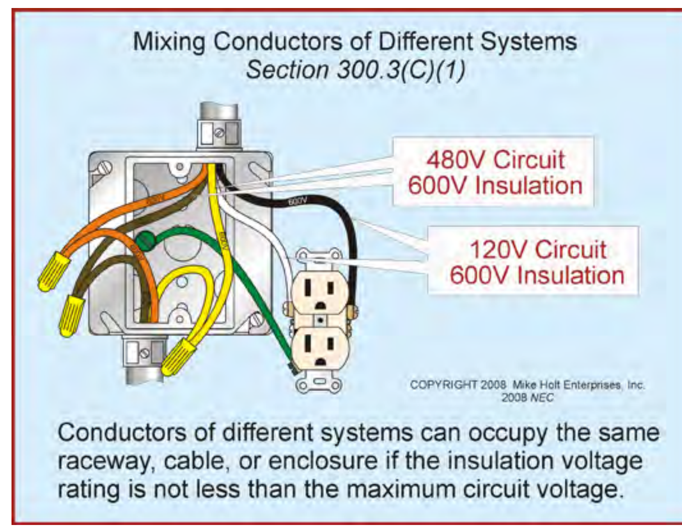

Figure 300–4

FPN: See 725.136(A) for Class 2 and Class 3 circuit conductors.

Author's Comments:

- Control, signal, and communications wiring must be separated from power and lighting circuits so the higher-voltage conductors don't accidentally energize the control, signal, or communications wiring:
  - CATV Coaxial Cable, 820.133(A)
  - Class 1, Class 2, and Class 3 Control Circuits, 725.48 and 725.136(A). Figure 300–5
  - Communications Circuits, 800.133(A)(1)(c)
  - Fire Alarm Circuits, 760.136(A)
  - Instrumentation Tray Cable, 727.5
  - Sound Circuits, 640.9(C)

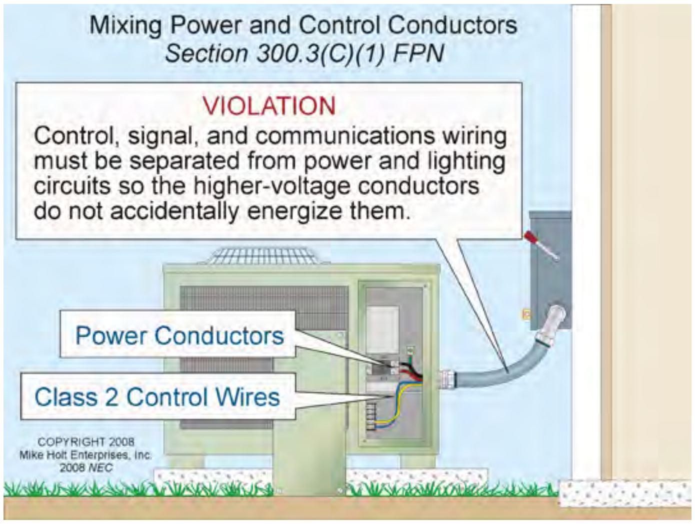

Figure 300–5

- A Class 2 circuit that has been reclassified as a Class 1 circuit [725.130(A) Ex 2] can be run with associated power conductors [725.48(B)(1)] if all conductors have an insulation voltage rating not less than the maximum circuit voltage [300.3(C)(1)]. Figure 300–6

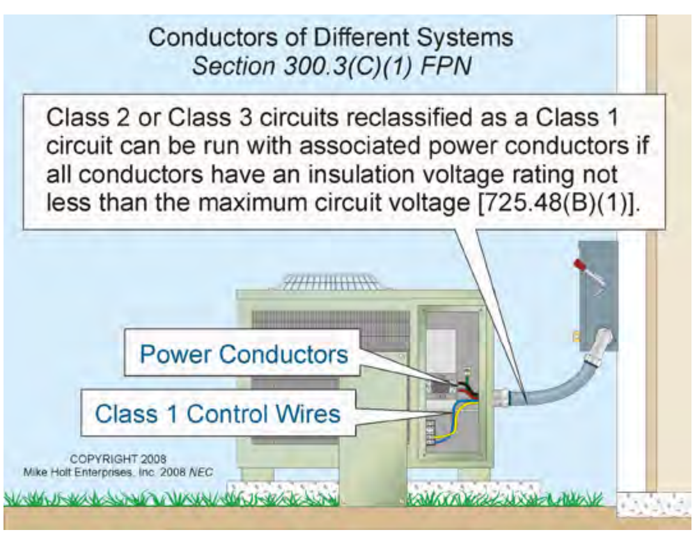

Figure 300–6

62 300.5 Underground Installations.

(A) Minimum Burial Depths. When cables or raceways are run underground, they must have a minimum “cover” in accordance with Table 300.5. Figure 300–7

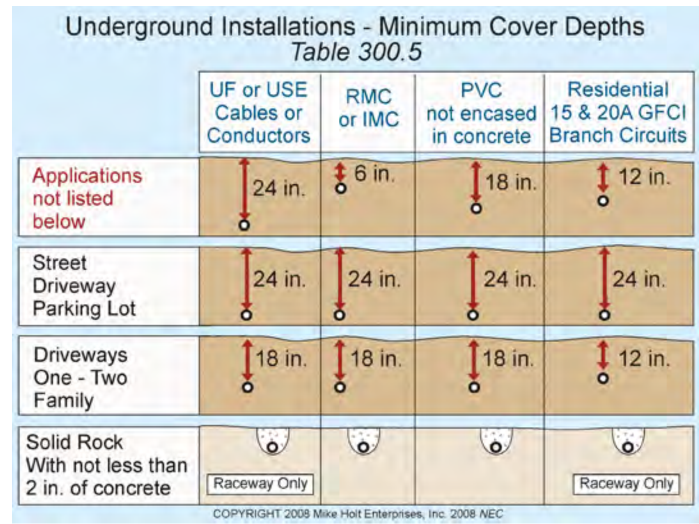

Figure 300–7

Author’s Comment: Note 1 to Table 300.5 defines “Cover” as the distance from the top of the underground cable or raceway to the surface of finish grade. Figure 300–8

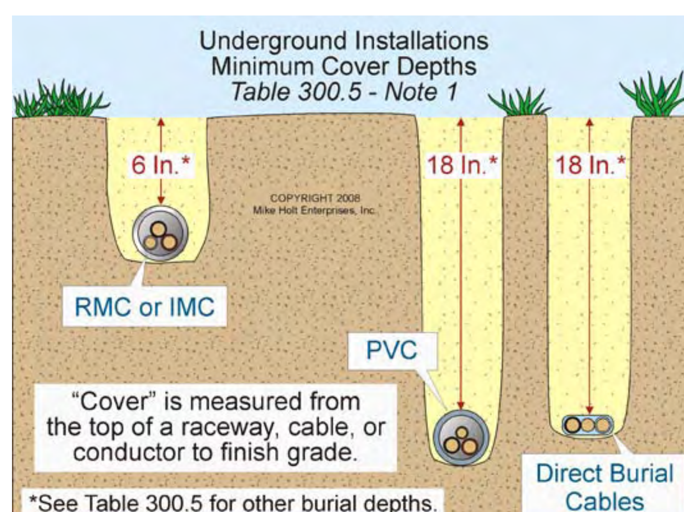

Figure 300–8

Table 300.5 Minimum Cover Requirements in Inches			
Location	Buried Cables	Metal Raceway	Nonmetallic Raceway
Under Building	0	0	0
Dwelling Unit	24/12*	6	18
Dwelling Unit Driveway	18/12*	6	18/12*
Under Roadway	24	24	24
Other Locations	24	6	18

**Residential branch circuits rated 120V or less with GFCI protection and maximum overcurrent protection of 20A. Note: This is a summary of NEC Table 300.5. See the table in the NEC for full details.*

Author's Comment: The cover requirements contained in 300.5 don't apply to the following signaling, communications and other power limited wiring: Figure 300–9

- CATV, 90.3
- Class 2 and 3 Circuits, 725.3
- Communications Cables and Raceways, 90.3
- Fire Alarm Circuits, 760.3
- Optical Fiber Cables and Raceways, 770.3

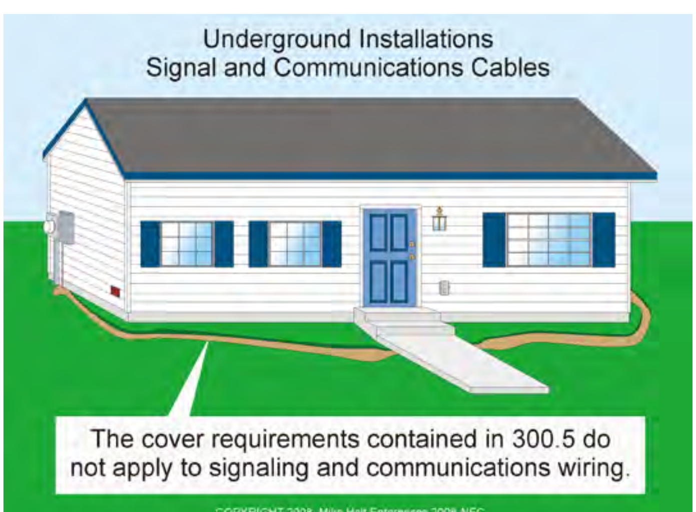

Figure 300–9

(B) Wet Locations. The interior of enclosures or raceways installed in an underground installation are considered to be a wet location. Cables and insulated conductors installed in underground enclosures or raceways must be listed for use in wet locations according to 310.8(C). Splices within an underground enclosure must be listed as suitable for wet locations [110.14(B)]. Figure 300–10

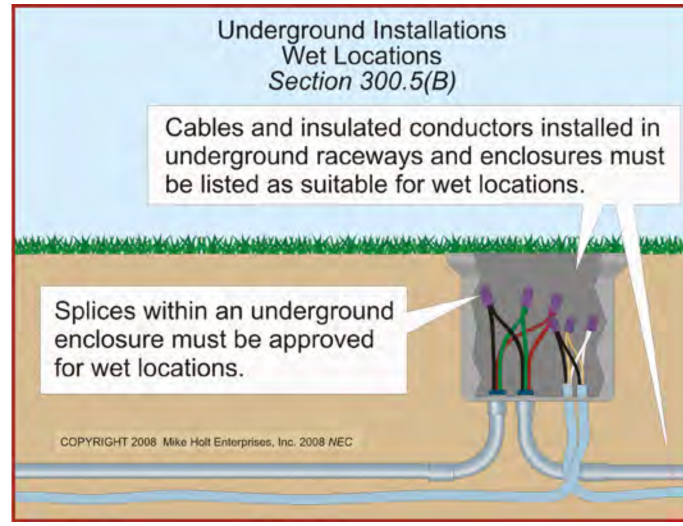

Figure 300–10

Author's Comment: The definition of a "Wet Location," as contained in Article 100, includes installations underground, in concrete slabs in direct contact with the earth, locations subject to saturation with water, and unprotected locations exposed to weather. Where raceways are installed in wet locations above grade, the interior of these raceways is also considered to be a wet location [300.9].

(C) Cables Under Buildings. Cables run under a building must be installed in a raceway that extends past the outside walls of the building.

(D) Protecting Underground Cables and Conductors. Direct-buried conductors and cables such as Types MC, UF and USE must be protected from damage in accordance with (1) through (4).

(1) Emerging from Grade. Direct-buried cables or conductors that emerge from grade must be installed in an enclosure or raceway to protect against physical damage. Protection isn't required to extend more than 18 in. below grade, and protection above ground must extend to a height not less than 8 ft. Figure 300–11

(2) Conductors Entering Buildings. Conductors that enter a building must be protected to the point of entrance.

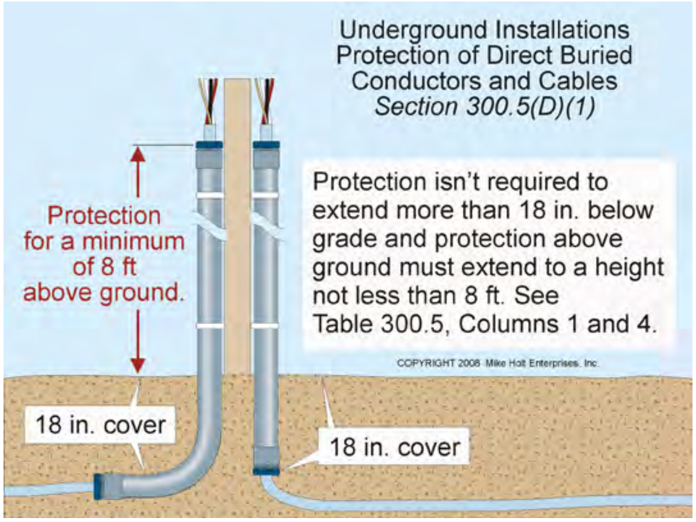

Figure 300–11

(3) Service Lateral Conductors. Direct-buried service-lateral conductors that aren't under the exclusive control of the electric utility, and are buried 18 in. or more below grade, must have their location identified by a warning ribbon placed in the trench not less than 1 ft above the underground installation. Figure 300–12

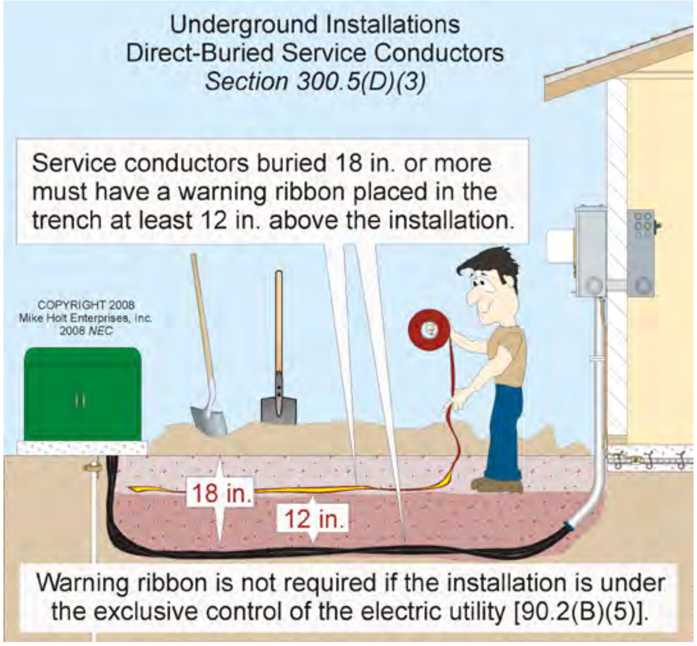

Figure 300–12

(4) Enclosure or Raceway Damage. Where direct-buried cables, enclosures, or raceways are subject to physical damage, the conductors must be installed in rigid metal conduit, intermediate metal conduit, or Schedule 80 PVC conduit.

(E) Underground Splices and Taps. Direct-buried conductors or cables can be spliced or tapped underground without a splice box [300.15(G)], if the splice or tap is made in accordance with 110.14(B). Figure 300–13

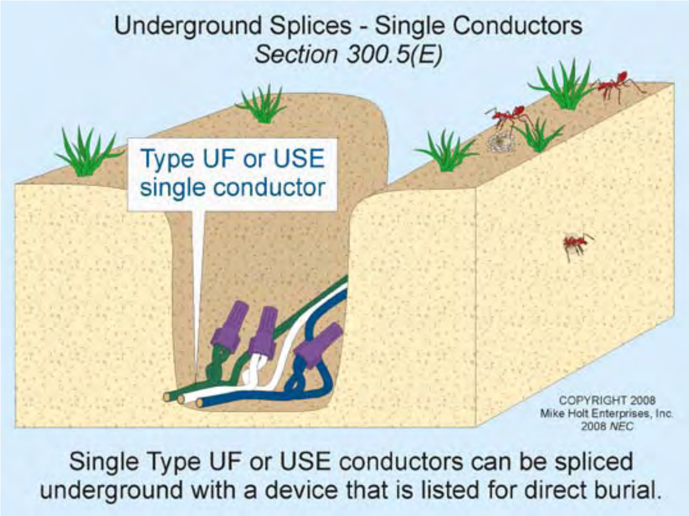

Figure 300–13

(F) Backfill. Backfill material for underground wiring must not damage the underground cable or raceway, or contribute to the corrosion of the metal raceway.

Author's Comment: Large rocks, chunks of concrete, steel rods, mesh, and other sharp-edged objects must not be used for backfill material, because they can damage the underground conductors, cables, or raceways.

(G) Raceway Seals. Where moisture could enter a raceway and contact energized live parts, a seal must be installed at one or both ends of the raceway.

Author's Comment: This is a common problem for equipment located downhill from the supply, or in underground equipment rooms. See 230.8 for service raceway seals and 300.7(A) for different temperature area seals.

FPN: Hazardous explosive gases or vapors make it necessary to seal underground conduits or raceways that enter the building in accordance with 501.15.

Author's Comment: It isn't the intent of this FPN to imply that sealing fittings of the types required in hazardous (classified) locations be installed in unclassified locations, except as required in Chapter 5. This also doesn't imply that the sealing material provides a watertight seal, but only that it prevents moisture from entering the conduits or raceways.

(H) Bushing. Raceways that terminate underground must have a bushing or fitting at the end of the raceway to protect emerging cables or conductors.

(I) Conductors Grouped Together. All conductors of the same circuit, including the equipment grounding conductor, must be inside the same raceway, or in close proximity to each other. See 300.3(B). Figure 300–14

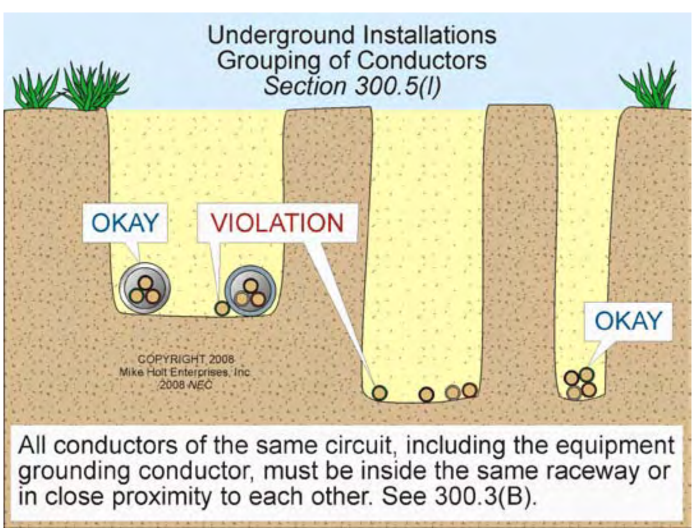

Figure 300–14

Exception No. 1: Conductors can be installed in parallel in accordance with 310.4.

Exception No. 2: Individual sets of parallel circuit conductors can be installed in underground PVC conduits, if inductive heating at raceway terminations is reduced by complying with 300.20(B) [300.3(B)(1) and 300.3(B)(3)]. Figure 300–15

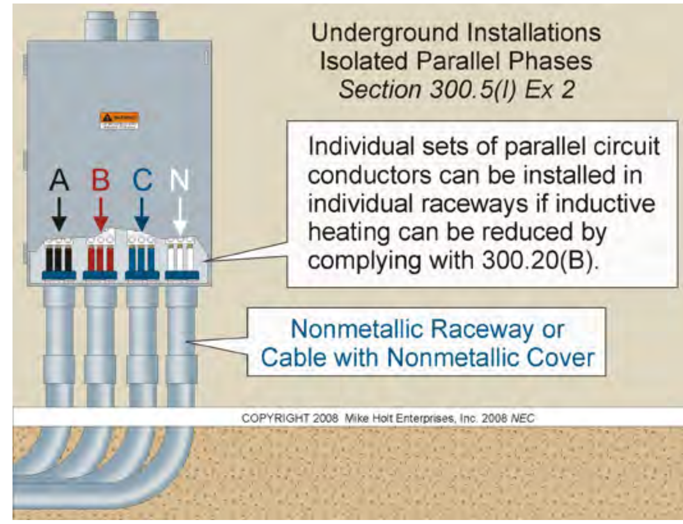

Figure 300–15

Author's Comment: Installing ungrounded and neutral conductors in different PVC conduits makes it easier to terminate larger parallel sets of conductors, but it will result in higher levels of electromagnetic fields (EMF), which can cause computer monitors to flicker in a distracting manner.

(J) Earth Movement. Direct-buried conductors, cables, or raceways that are subject to movement by settlement or frost must be arranged to prevent damage to conductors or equipment connected to the wiring.

(K) Directional Boring. Cables or raceways installed using directional boring equipment must be approved by the authority having jurisdiction for this purpose.

Author's Comment: Directional boring technology uses a directional drill, which is steered continuously from point "A" to point "B." When the drill head comes out of the earth at point "B," it's replaced with a back-reamer and the duct or conduit being installed is attached to it. The size of the boring rig (hp, torque, and pull-back power) comes into play, along with the types of soil, in determining the type of raceways required. For telecom work, multiple poly innerducts are pulled in at one time. At major crossings, such as expressways, railroads, or rivers, outerduct may be installed to create a permanent sleeve for the innerducts.

"Innerduct" and "outerduct" are terms usually associated with optical fiber cable installations, while "unitduct" comes with conductors factory installed. All of these come in various sizes. Galvanized rigid metal conduit, schedule 40 and schedule 80 PVC, HDPE conduit and nonmetallic underground conduit with conductors (NUCC) are common wiring methods used with directional boring installations.

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300.10 Electrical Continuity.

Metal raceways, cables, boxes, fittings, cabinets, and enclosures for conductors must be metallically joined together to form a continuous, low-impedance fault current path capable of carrying any fault current likely to be imposed on it [110.10, 250.4(A)(3), and 250.122]. Figure 300–16

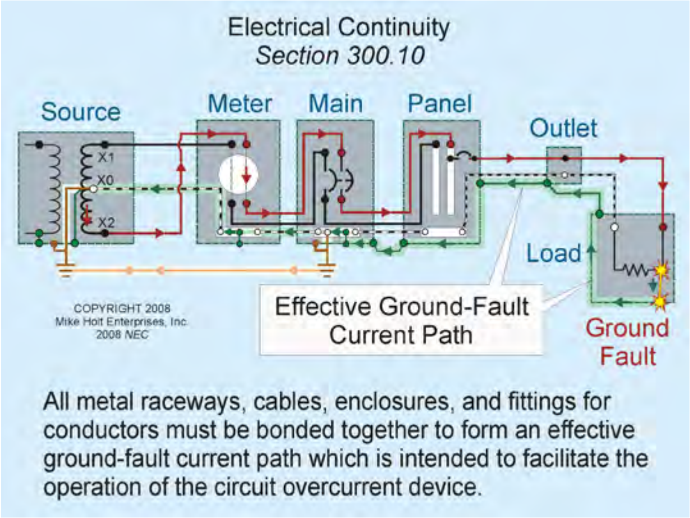

Figure 300–16

Metal raceways and cable assemblies must be mechanically secured to boxes, fittings, cabinets, and other enclosures.

Exception No. 1: Short lengths of metal raceways used for the support or protection of cables aren't required to be electrically continuous, nor are they required to be connected to an equipment grounding conductor of a type recognized in 250.118 [250.86 Ex 2 and 300.12 Ex]. Figure 300–17

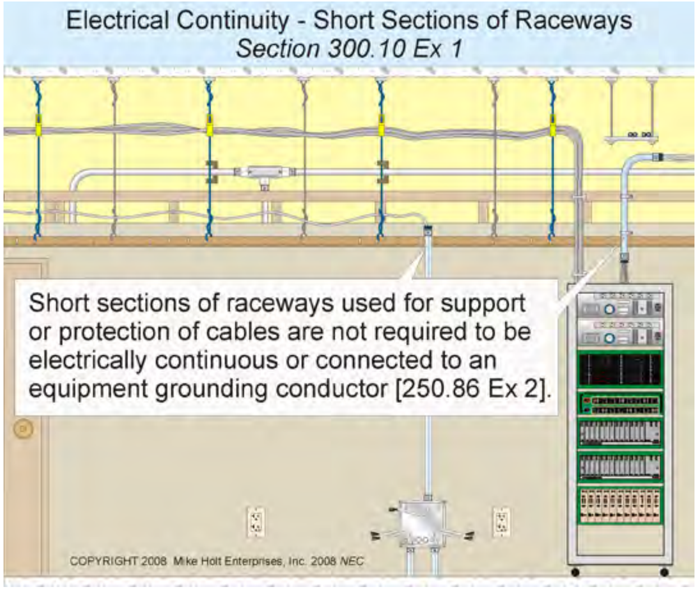

Figure 300–17

64

300.11 Securing and Supporting.

(A) Secured in Place. Raceways, cable assemblies, boxes, cabinets, and fittings must be securely fastened in place. The ceiling-support wires or ceiling grid must not be used to support raceways and cables (power, signaling, or communications). However, independent support wires that are secured at both ends and provide secure support are permitted. Figure 300–18

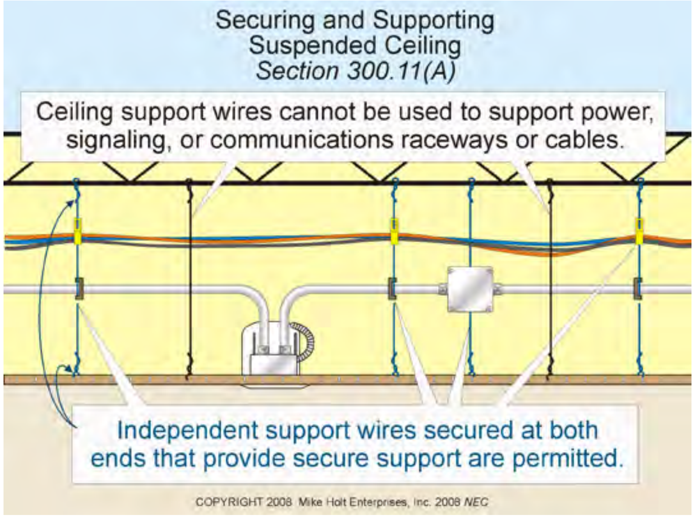

Figure 300–18

Author's Comment: Outlet boxes [314.23(D)] and luminaires can be secured to the suspended-ceiling grid if securely fastened to the ceiling-framing member by mechanical means such as bolts, screws, or rivets, or by the use of clips or other securing means identified for use with the type of ceiling-framing member(s) [410.36(B)].

(1) Fire-Rated Assembly. Electrical wiring within the cavity of a fire-rated floor-ceiling or roof-ceiling assembly can be supported by independent support wires attached to the ceiling assembly. The independent support wires must be distinguishable from the suspended-ceiling support wires by color, tagging, or other effective means.

(2) Nonfire-Rated Assembly. Wiring in a nonfire-rated floor-ceiling or roof-ceiling assembly is not permitted to be secured to, or supported by, the ceiling assembly, including the ceiling support wires. Independent support wires used for support can be attached to the nonfire-rated assembly.

> **Author's Comment:** Support wires within nonfire-rated assemblies aren't required to be distinguishable from the suspended-ceiling framing support wires. Most suspended ceiling systems are not part of a fire-resistance rated assembly.

(B) Raceways Used for Support. Raceways must not be used as a means of support for other raceways, cables, or nonelectrical equipment, except as permitted in (1) through (3). Figure 300–19

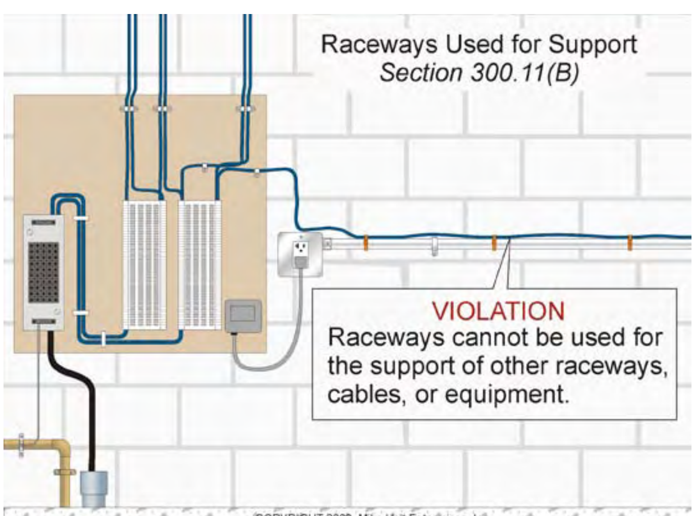

Figure 300–19

(1) Identified. Where the raceway or means of support is identified for the purpose.

(2) Class 2 and 3 Circuits. Class 2 and 3 cable can be supported by the raceway that supplies power to the equipment controlled by the Class 2 or 3 circuit. Figure 300–20

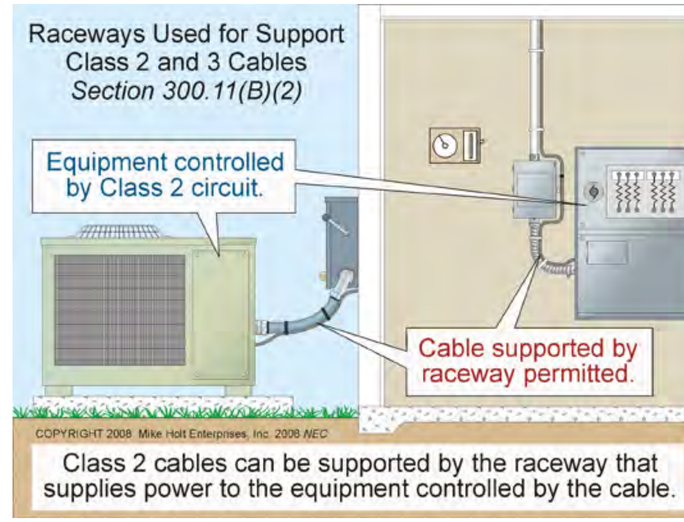

Figure 300–20

(3) Boxes Supported by Raceways. Raceways are permitted as a means of support for threaded boxes and conduit bodies in accordance with 314.23(E) and (F), or to support luminaires in accordance with 410.36(E).

(C) Cables Not Used as Means of Support. Cables must not be used to support other cables, raceways, or nonelectrical equipment. Figure 300–21

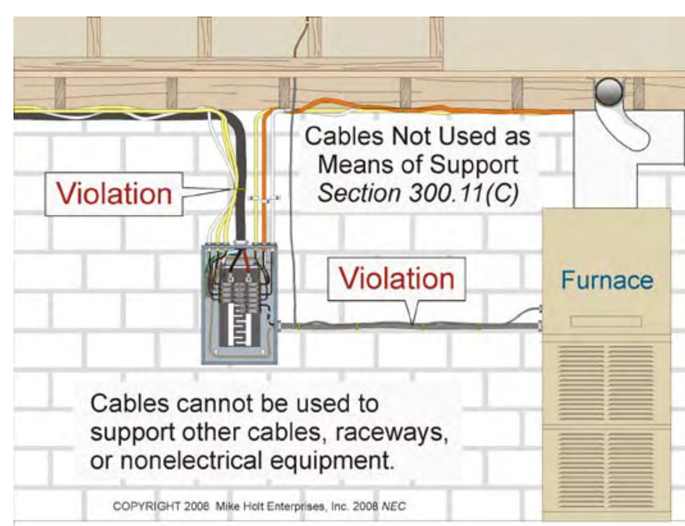

Figure 300–21

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300.12 Mechanical Continuity. Raceways and cable sheaths must be mechanically continuous between boxes, cabinets, and fittings. Figure 300–22

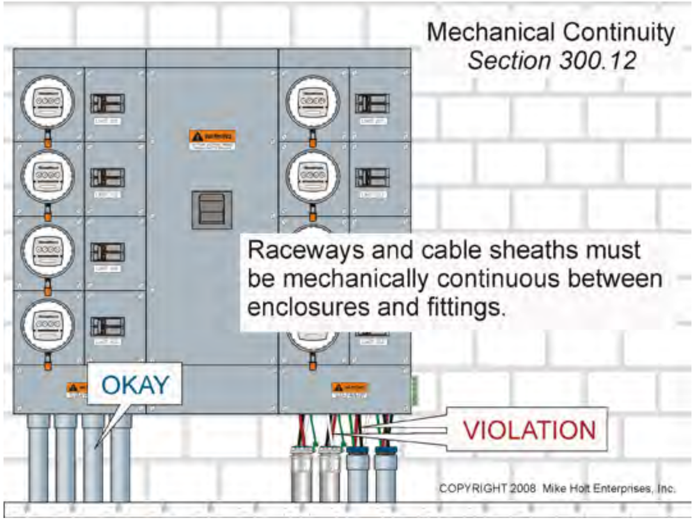

Figure 300–22

Exception No. 1: Short sections of raceways used to provide support or protection of cable from physical damage aren't required to be mechanically continuous [250.86 Ex 2 and 300.10 Ex 1]. Figure 300–23

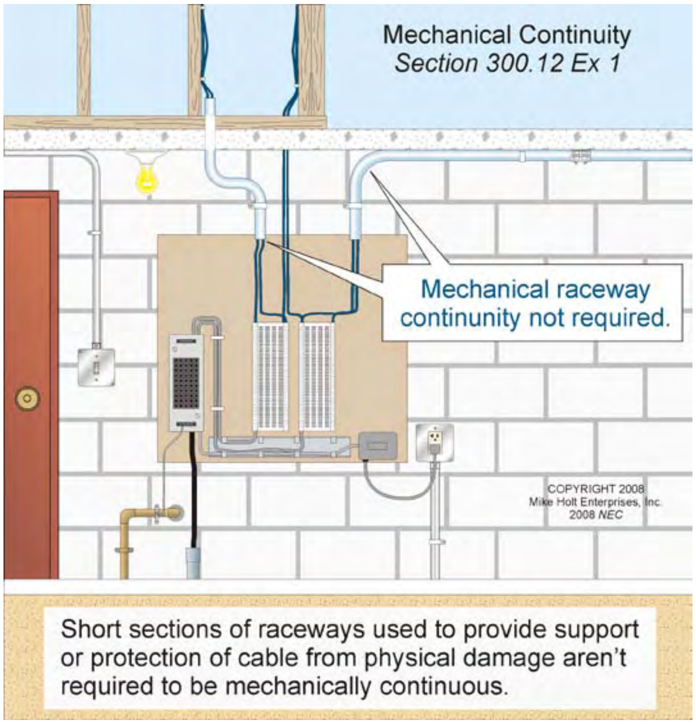

Figure 300–23

Exception No. 2: Raceways at the bottom of open-bottom equipment, such as switchboards, motor control centers, and transformers, are not required to be mechanically secured to the equipment. Figure 300–24

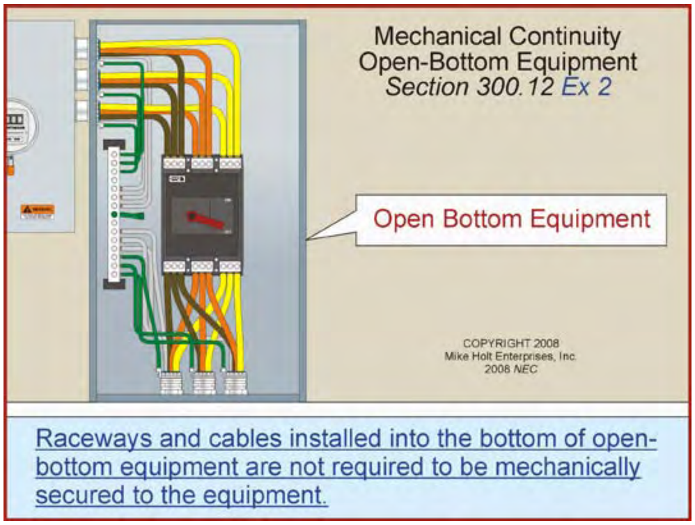

Figure 300–24

Author's Comment: When raceways are stubbed into an open-bottom switchboard or other apparatus, the raceway, including the end fitting, can't rise more than 3 in. above the bottom of the switchboard enclosure [408.5].

66 300.13 Splices and Pigtails.

(A) Conductor Splices. Conductors in raceways must be continuous between all points of the system, which means splices must not be made in raceways, except as permitted by 376.56, 378.56, 384.56, 386.56, or 388.56. See 300.15. Figure 300–25

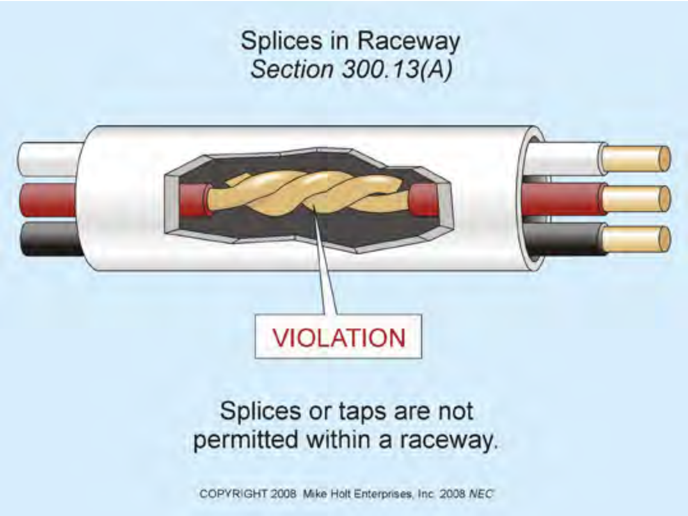

Figure 300–25

(B) Conductor Continuity. Continuity of the neutral conductor of a multiwire branch circuit must not be interrupted by the removal of a wiring device. In these applications the neutral conductors must be spliced together, and a "pigtail" must be provided for the wiring device. Figure 300–26

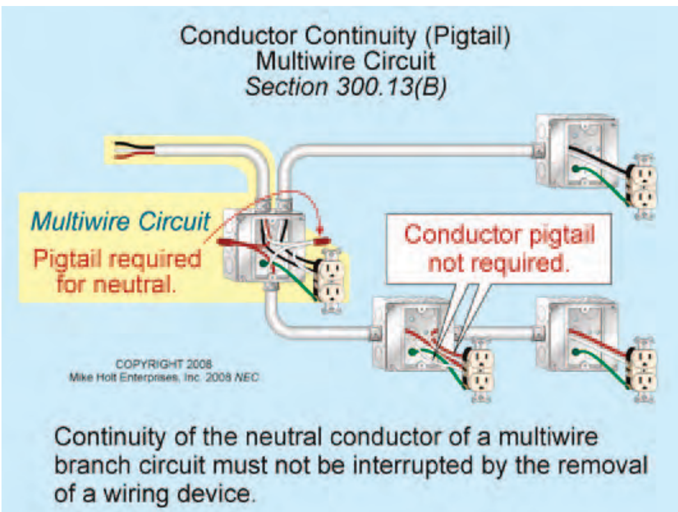

Figure 300–26

Author's Comment: The opening of the ungrounded conductors, or the neutral conductor of a 2-wire circuit during the replacement of a device, doesn't cause a safety hazard, so pigtailing of these conductors isn't required [110.14(B)].

CAUTION: *If the continuity of the neutral conductor of a multiwire circuit is interrupted (open), the resultant over- or undervoltage can cause a fire and/or destruction of electrical equipment.*

Example: *A 3-wire, single-phase, 120/240V multiwire circuit supplies a 1,200W, 120V hair dryer and a 600W, 120V television. If the neutral conductor of the multiwire circuit is interrupted, it will cause the 120V television to operate at 160V and consume 1,067W of power (instead of 600W) for only a few seconds before it burns up.* Figure 300–27

Step 1: Determine the resistance of each appliance, $R = E^2/P$.

R of the hair dryer = $120V^2/1,200W$
R of the hair dryer = 12 ohms

R of the television = $120V^2/600W$
R of the television = 24 ohms

Step 2: Determine the current of the circuit, I = E/R.

E = 240V

R = 36 ohms (12 ohms + 24 ohms)
I = 240V/36 ohms
I = 6.70A

Step 3: Determine the operating voltage for each appliance, E = I x R.

I – 6.70A

R = 12 ohms for dryer and 24 ohms for TV

Voltage of hair dryer = 6.70A x 12 ohms
Voltage of hair dryer = 80V

Voltage of television = 6.70A x 24 ohms
Voltage of Television = 160V

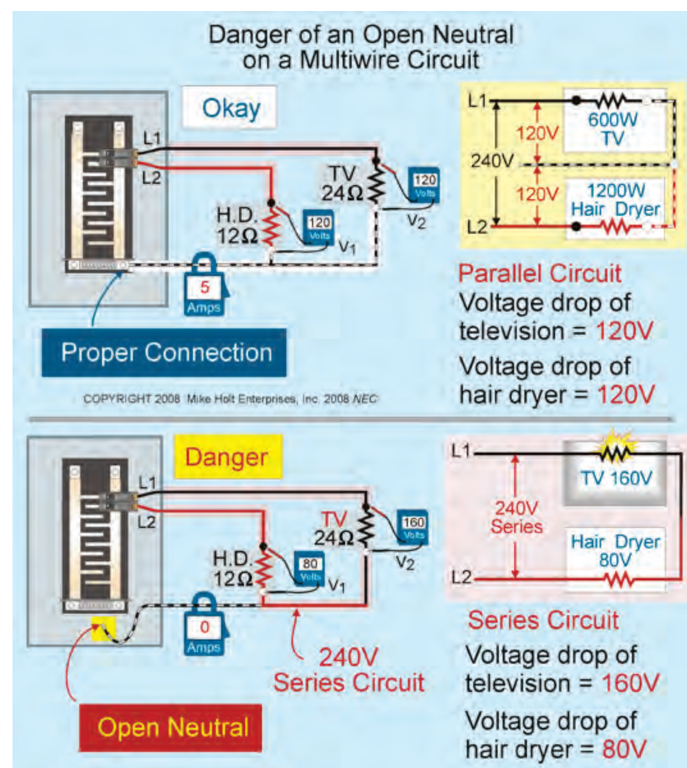

Figure 300–27

WARNING: *Failure to terminate the ungrounded conductors to separate phases can cause the neutral conductor to become overloaded, and the insulation can be damaged or destroyed by excessive heat. Conductor overheating is known* *to decrease the service life of insulating materials, which creates the potential for arcing faults in hidden locations, and could ultimately lead to fires. It isn't known just how long conductor insulation lasts, but heat does decrease its life span.* Figure 300–28

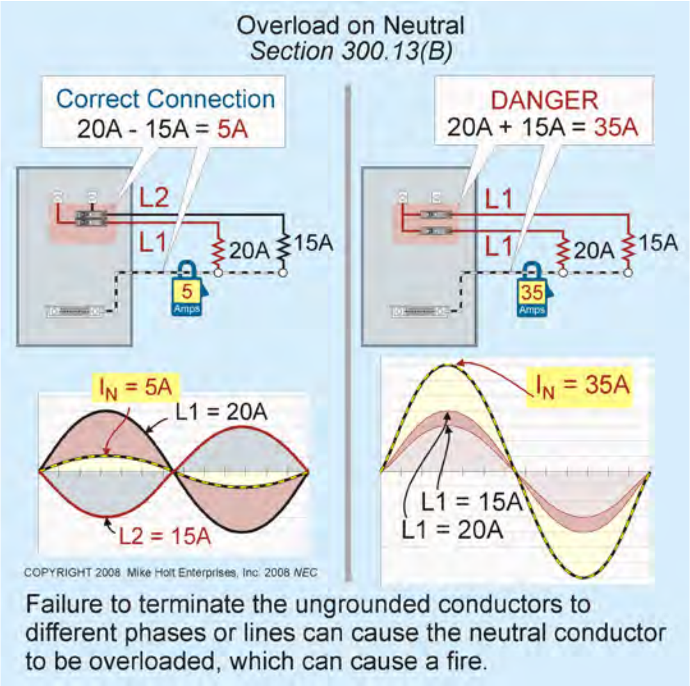

Figure 300–28

67 300.15 Boxes or Conduit Bodies.

A box must be installed at each splice or termination point, except as permitted for: Figure 300–29

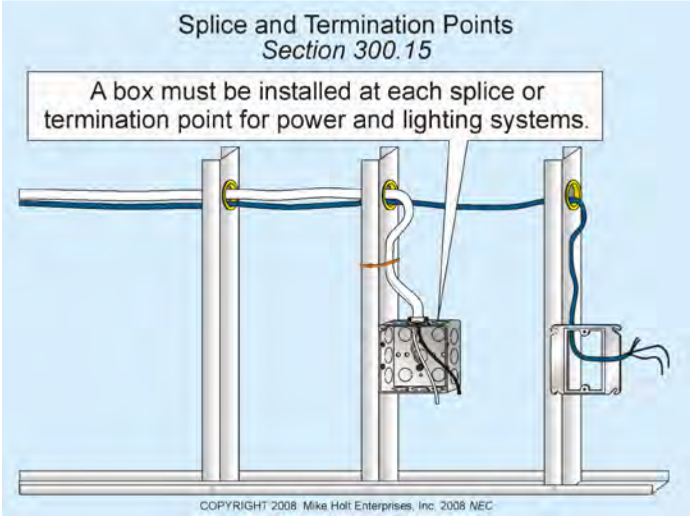

Figure 300–29

- Cabinet or Cutout Boxes, 312.8
- Conduit Bodies, 314.16(C) Figure 300–30
- Luminaires, 410.64
- Surface Raceways, 386.56 and 388.56
- Wireways, 376.56

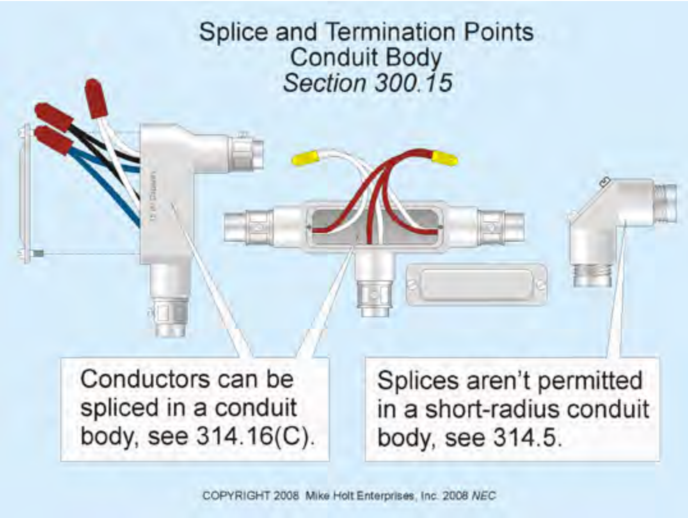

Figure 300–30

Author's Comment: Boxes aren't required for the following signaling and communications cables or raceways: Figure 300–31

- CATV, 90.3
- Class 2 and 3 Control and Signaling, 725.3
- Communications, 90.3
- Optical Fiber, 770.3

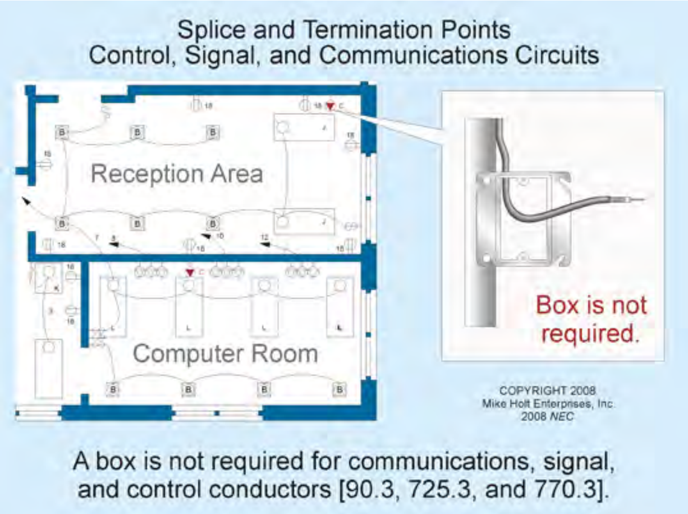

Figure 300–31

Fittings and Connectors. Fittings can only be used with the specific wiring methods for which they are listed and designed. For example, Type NM cable connectors must not be used with Type AC cable, and electrical metallic tubing fittings must not be used with rigid metal conduit or intermediate metal conduit, unless listed for the purpose. Figure 300–32

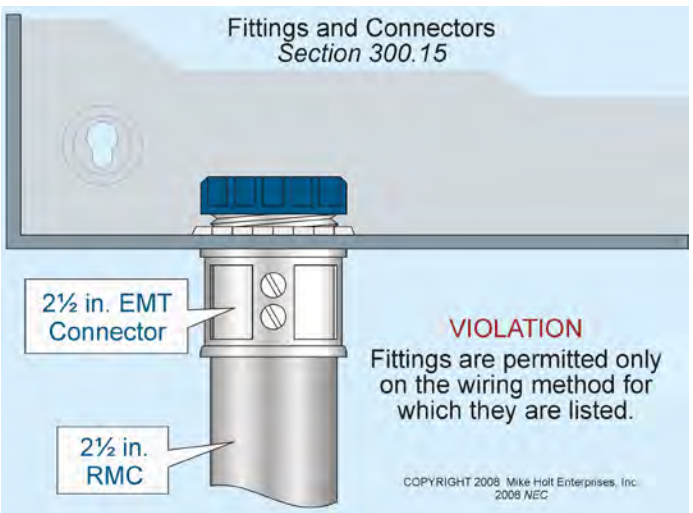

Figure 300–32

> **Author's Comment:** PVC conduit couplings and connectors are permitted with electrical nonmetallic tubing if the proper glue is used in accordance with manufacturer's instructions [110.3(B)]. See 362.48.

(C) Raceways for Support or Protection. When a raceway is used for the support or protection of cables, a fitting to reduce the potential for abrasion must be placed at the location the cables enter the raceway. Figure 300–33

(F) Fitting. A fitting is permitted in lieu of a box or conduit body where conductors are not spliced or terminated within the fitting if it's accessible after installation. Figure 300–34

(G) Underground Splices. A box or conduit body isn't required where a splice is made underground if the conductors are spliced with a splicing device listed for direct burial. See 110.14(B) and 300.5(E).

> **Author's Comment:** See the definition of "Conduit Body" in Article 100.

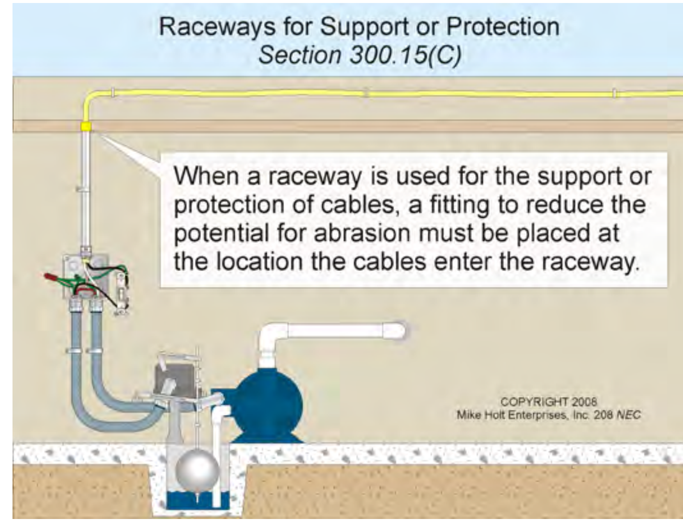

Figure 300–33

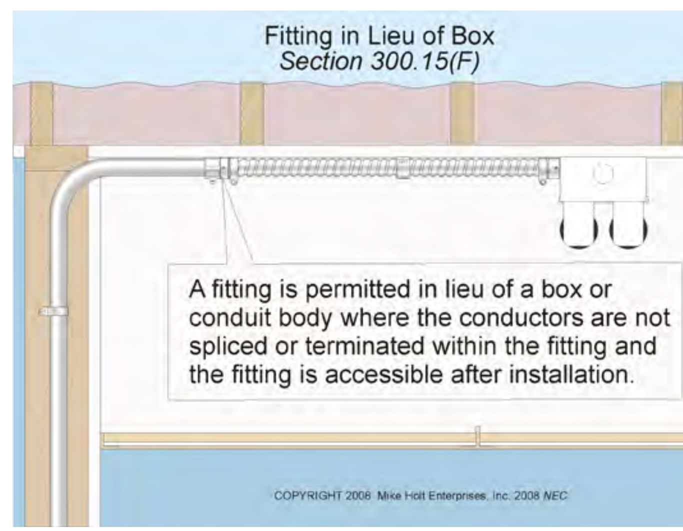

Figure 300–34

(I) Enclosures. A box or conduit body isn't required where a splice is made in a cabinet or in cutout boxes containing switches or overcurrent devices if the splices or taps don't fill the wiring space at any cross section to more than 75 percent, and the wiring at any cross section doesn't exceed 40 percent. See 312.8 and 404.3(B). Figure 300–35

> **Author's Comment:** See the definitions of "Cabinet" and "Cutout Box" in Article 100.

(J) Luminaires. A box or conduit body isn't required where a luminaire is used as a raceway as permitted in 410.64 and 410.65.

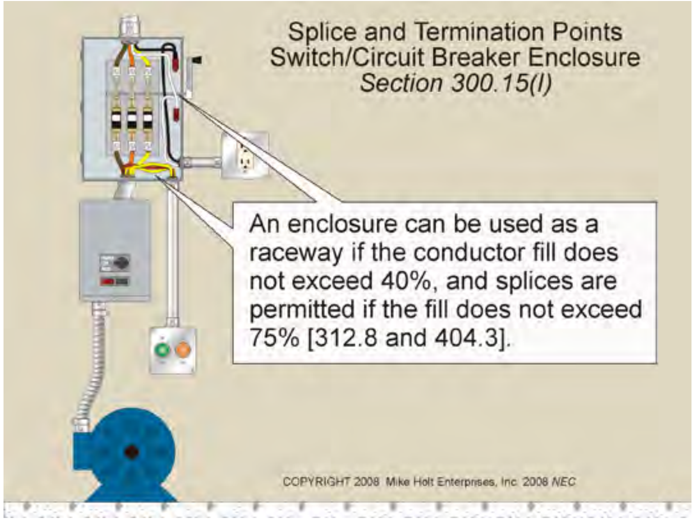

Figure 300–35

(L) Handhole Enclosures. A box or conduit body isn't required for conductors installed in a handhole enclosure. Splices must be made in accordance with 314.30. Figure

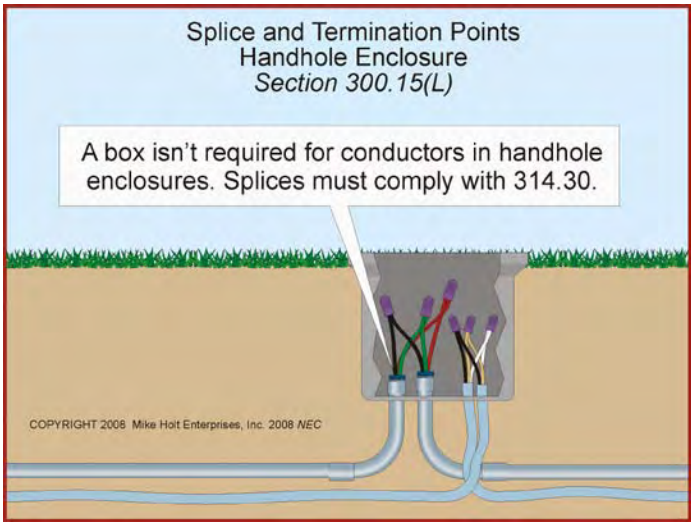

Figure 300–36

300–36

Author's Comment: Splices or terminations within a handhole must be accomplished by the use of fittings listed as suitable for wet locations [110.14(B) and 314.30(C)].

68 300.20 Induced Currents in Ferrous Metal Enclosures and Raceways.

(A) Conductors Grouped Together. To minimize induction heating of ferrous metal raceways and ferrous metal enclosures for alternating-current circuits, and to maintain an effective ground-fault current path, all conductors of a circuit must be installed in the same raceway, cable, trench, cord, or cable tray. See 250.102(E), 300.3(B), 300.5(I), and 392.8(D). Figure 300–37

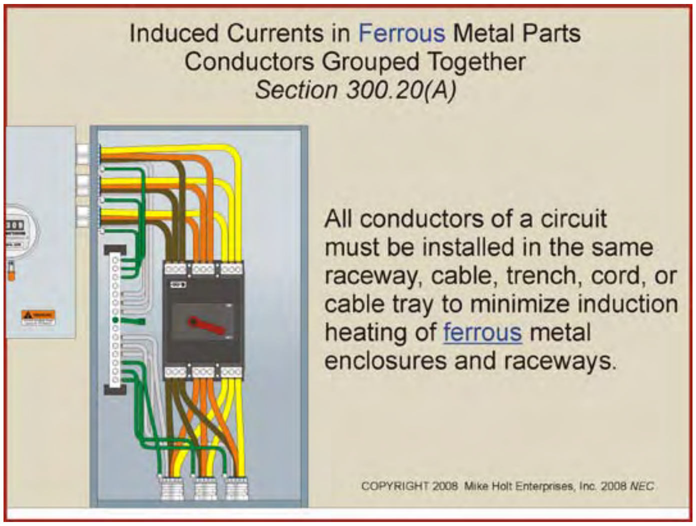

Figure 300–37

Author's Comment: When alternating current (ac) flows through a conductor, a pulsating or varying magnetic field is created around the conductor. This magnetic field is constantly expanding and contracting with the amplitude of the ac current. In the United States, the frequency is 60 cycles per second (Hz). Since ac reverses polarity 120 times per second, the magnetic field that surrounds the conductor also reverses its direction 120 times per second. This expanding and collapsing magnetic field induces eddy currents in the ferrous metal parts that surround the conductors, causing the metal parts to heat up from hysteresis.

Magnetic materials naturally resist the rapidly changing magnetic fields. The resulting friction produces its own additional heat - hysteresis heating - in addition to eddy current heating. A metal which offers high resistance is said to have high magnetic "permeability." Permeability can vary on a scale of 100 to 500 for magnetic materials; nonmagnetic materials have a permeability of one.

Simply put, the molecules of steel and iron align to the polarity of the magnetic field and when the magnetic field reverses, the molecules reverse their polarity as well. This back-and-forth alignment of the molecules heats up the metal, and the more the current flows, the greater the heat rises in the ferrous metal parts. Figure 300–38

When conductors of the same circuit are grouped together, the magnetic fields of the different conductors tend to cancel each other out, resulting in a reduced magnetic field around the conductors. The lower magnetic field reduces induced currents in the ferrous metal raceways or enclosures, which reduces hysteresis heating of the surrounding metal enclosure.

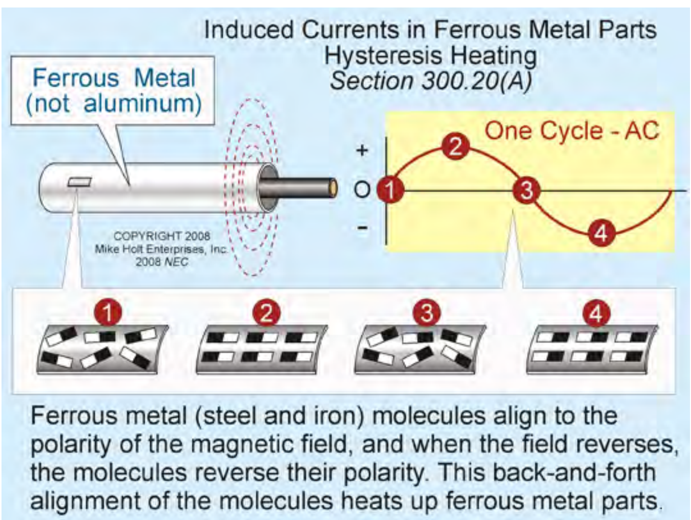

Figure 300–38

WARNING: *There has been much discussion in the press on the effects of electromagnetic fields on humans. According to the Institute of Electrical and Electronics Engineers (IEEE), there's insufficient information at this time to define an unsafe electromagnetic field level.*

(B) Single Conductors. When single conductors are installed in nonmetallic raceways as permitted in 300.5(I) Ex 2, the inductive heating of the metal enclosure must be minimized by the use of aluminum locknuts and by cutting a slot between the individual holes through which the conductors pass. Figure 300–39

FPN: Because aluminum is a nonmagnetic metal, aluminum parts don't heat up due to hysteresis.

Author's Comment: Aluminum conduit, locknuts, and enclosures carry eddy currents, but because aluminum is nonferrous, it doesn't heat up [300.20(B) FPN].

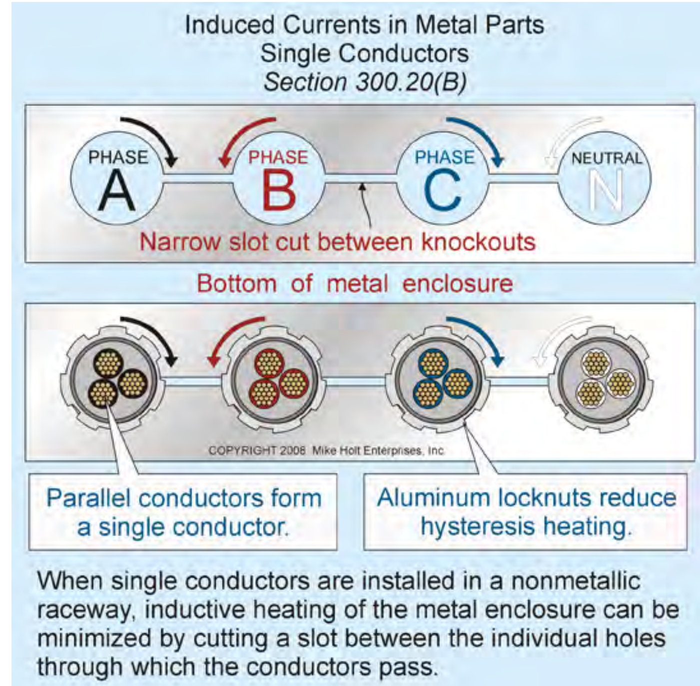

Figure 300–39

69 300.21 Spread of Fire or Products of Combustion.

Electrical circuits and equipment must be installed in such a way that the spread of fire or products of combustion will not be substantially increased. Openings in fire-rated walls, floors, and ceilings for electrical equipment must be fire-stopped using methods approved by the authority having jurisdiction to maintain the fire-resistance rating of the fire-rated assembly.

Author's Comment: Fire-stopping materials are listed for the specific types of wiring methods and the construction of the assembly that they penetrate.

FPN: Directories of electrical construction materials published by qualified testing laboratories contain listing and installation restrictions necessary to maintain the fire-resistive rating of assemblies. Outlet boxes must have a horizontal separation not less than 24 in. when installed in a fire-rated assembly, unless an outlet box is listed for closer spacing or protected by fire-resistant "putty pads" in accordance with manufacturer's instructions.

Author's Comments:

- Boxes installed in fire-resistance rated assemblies must be listed for the purpose. Where steel boxes are used, they must be secured to the framing member, so cut-in type boxes are not allowed (UL White Book, product category QCIT).
- This rule also applies to control, signal, and communications cables or raceways. Figure 300–40
  - CATV, 820.26
  - Communications, 800.26
  - Control and Signaling, 725.25
  - Fire Alarm, 760.3(A)
  - Optical Fiber, 770.26
  - Sound Systems, 640.3(A)

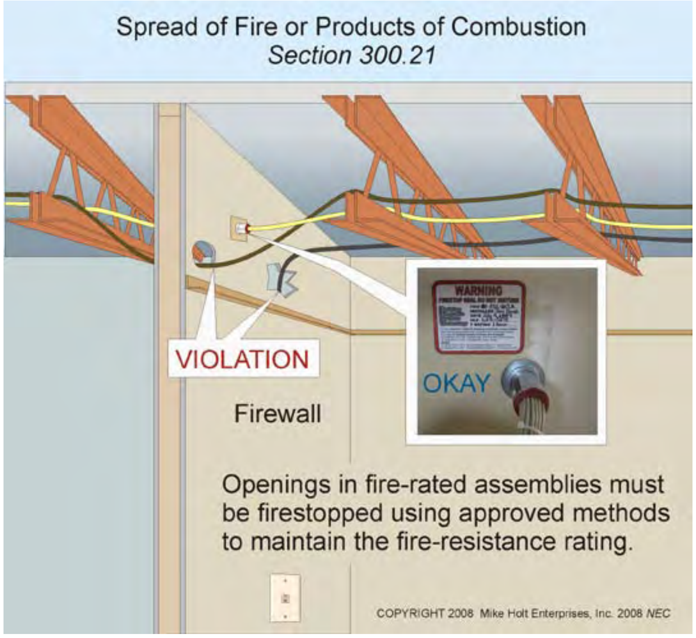

Figure 300–40

70 300.22 Ducts, Plenums, and Other Air-Handling Spaces.

(A) Ducts Used for Dust, Loose Stock, or Vapor. Ducts that transport dust, loose stock, or vapors must not have any wiring method installed within them. Figure 300–41

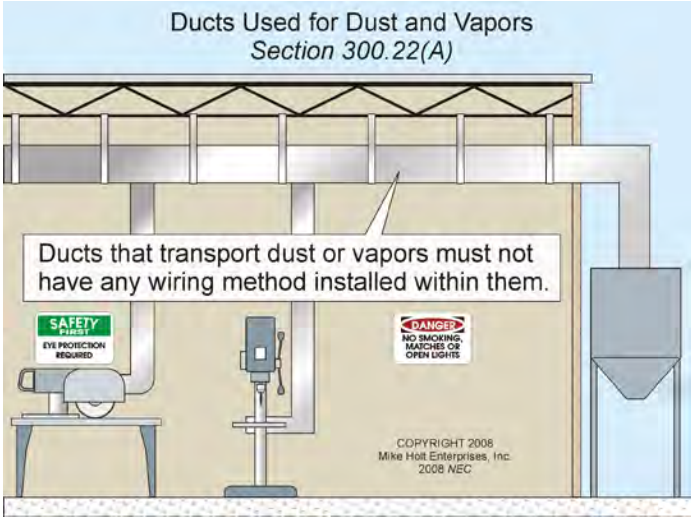

Figure 300–41

(B) Ducts or Plenums Used for Environmental Air. Where necessary for direct action upon, or sensing of, the contained air, Type MI cable, Type MC cable that has a smooth or corrugated impervious metal sheath without an overall nonmetallic covering, electrical metallic tubing, flexible metallic tubing, intermediate metal conduit, or rigid metal conduit without an overall nonmetallic covering can be installed in ducts or plenums specifically fabricated to transport environmental air. Figure 300–42

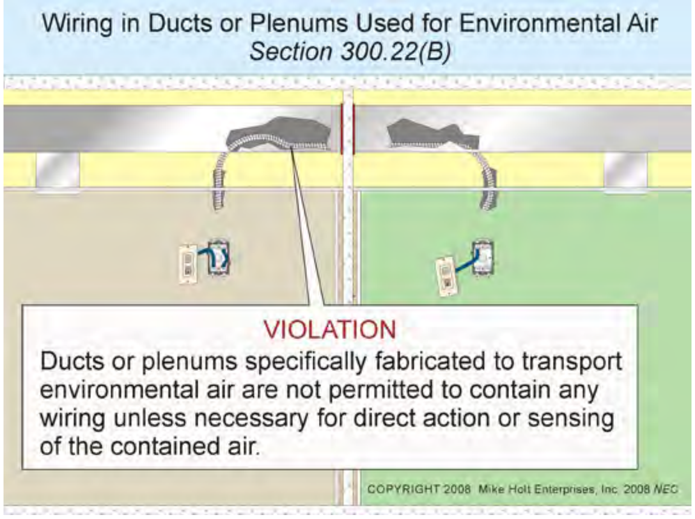

Figure 300–42

Author's Comment: See the definition of "Plenum" in Article 100.

Flexible metal conduit in lengths not exceeding 4 ft can be used to connect physically adjustable equipment and devices, provided any openings are effectively closed.

Where equipment or devices are installed and illumination is necessary to facilitate maintenance and repair, enclosed gasketed-type luminaires are permitted.

(C) Other Space Used for Environmental Air Space. Wiring and equipment in spaces used for environmental air-handling purposes must comply with (1) and (2). This requirement doesn't apply to habitable rooms or areas of buildings, the prime purpose of which isn't air handling.

> **FPN:** The spaces above a suspended ceiling or below a raised floor used for environmental air are examples of the type of space to which this section applies. Figure 300–43

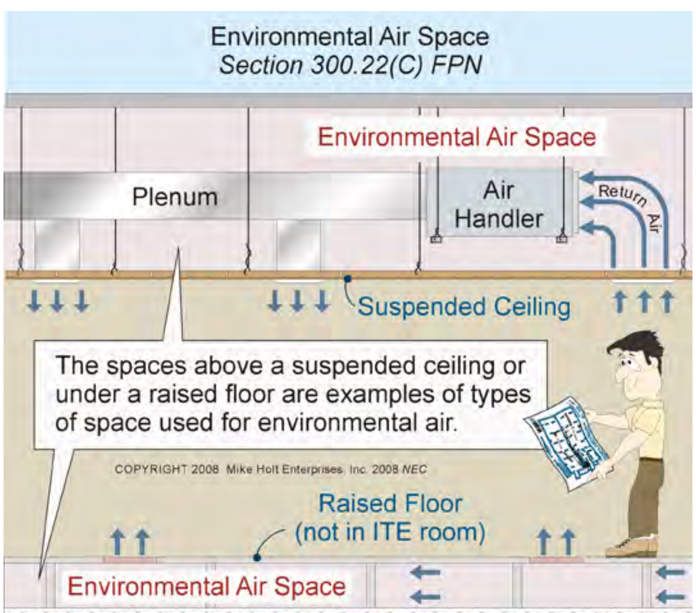

Figure 300–43

(1) Wiring Methods Permitted. Electrical metallic tubing, rigid metal conduit, intermediate metal conduit, armored cable, metal-clad cable without a nonmetallic cover, and flexible metal conduit can be installed in environmental air spaces.

Where accessible, surface metal raceways, metal wireways with metal covers, or solid bottom metal cable tray with solid metal covers can be installed in environmental air spaces.

Author's Comments:

- PVC conduit [Article 352], electrical nonmetallic tubing [Article 362], liquidtight flexible conduit, and nonmetallic cables are not permitted to be installed in spaces used for environmental air because they give off deadly toxic fumes when burned or superheated.
- Control, signaling, and communications cables installed in spaces used for environmental air must be suitable for plenum use. Figure 300–44
  - CATV, 820.179(A)
  - Communications, 800.21
  - Control and Signaling, 725.154(A)
  - Fire Alarm, 760.7
  - Optical Fiber Cables and Raceways, 770.154(A)
  - Sound Systems, 640.9(C) and 725.154(A)

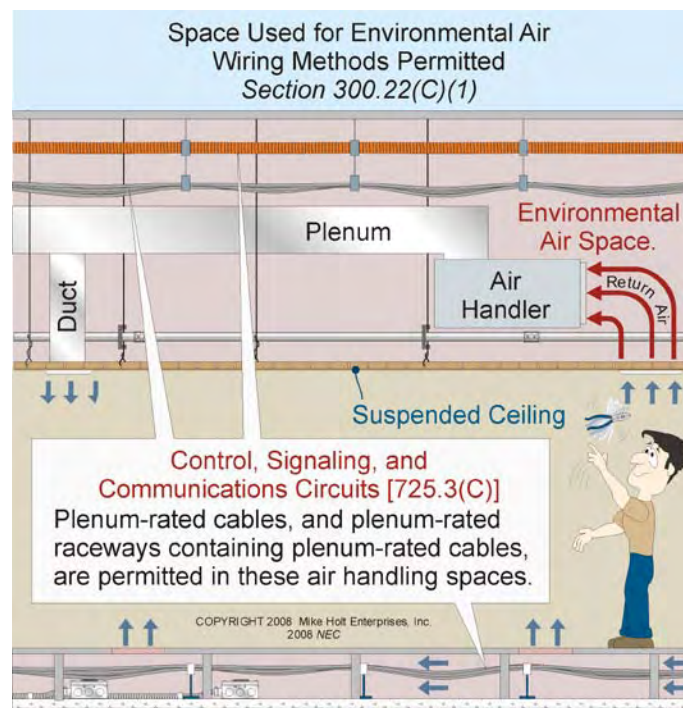

Figure 300–44

- Any wiring method suitable for the condition can be used in a space not used for environmental air-handling purposes. Figure 300–45

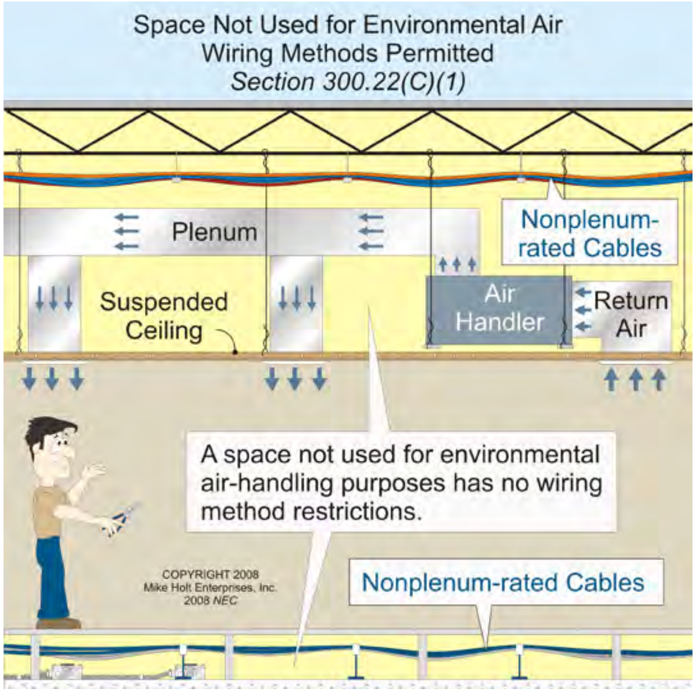

Figure 300–45

(2) Equipment. Electrical equipment constructed with a metal enclosure is permitted in a space used for environmental air.

> **Author's Comment:** Dry-type transformers with a metal enclosure, rated not over 50 kVA, can be installed above suspended ceilings used for environmental air [450.13(B)]. Figure 300–46

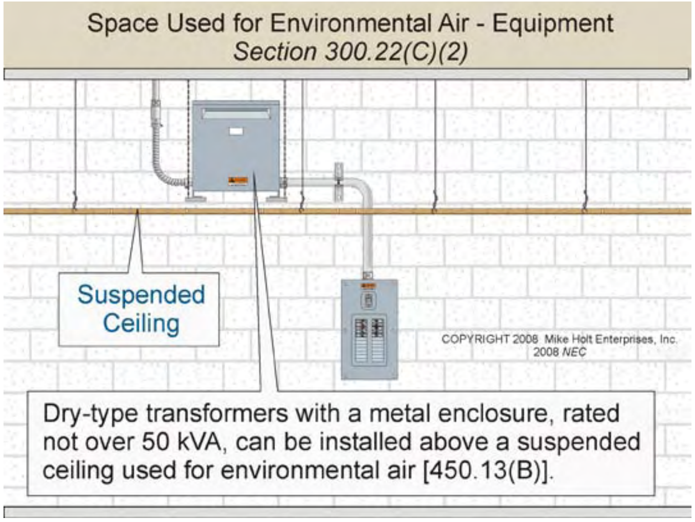

Figure 300–46

(D) Information Technology Equipment Rooms. Wiring in air-handling areas under a raised floor in an information technology room must comply with 645.5(D). Figure 300–47

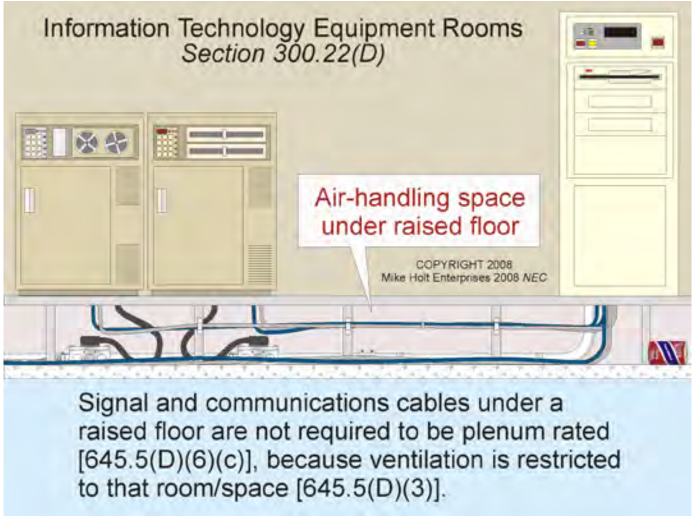

Figure 300–47

> **Author's Comment:** Signal and communications cables under a raised floor are not required to be suitable for plenum use [645.5(D)(6)(c)], because ventilation is restricted to that room/space, and the space is not normally occupied [645.5(D)(4)].

ARTICLE

310 Conductors for General Wiring

INTRODUCTION TO ARTICLE 310—CONDUCTORS FOR GENERAL WIRING

This article contains the general requirements for conductors, such as insulation markings, ampacity ratings, and conditions of use. Article 310 doesn't apply to conductors that are part of flexible cords, fixture wires, or to conductors that are an integral part of equipment [90.7 and 300.1(B)].

People often make errors in applying the ampacity tables contained in Article 310. If you study the explanations carefully, you'll avoid common errors such as applying Table 310.17 when you should be applying Table 310.16. Why so many tables? Why does Table 310.17 list the ampacity of 6 THHN as 105 amperes, yet Table 310.16 lists the same conductor as having an ampacity of only 75 amperes? To answer that, go back to Article 100 and review the definition of ampacity. Notice the phrase "conditions of use." What these tables do is set a maximum current value at which you can ensure the installation won't undergo premature failure of the conductor insulation in normal use, in the conditions described in the tables.

The designations THHN, THHW, RHH, and so on, are insulation types. Every type of insulation has a heat withstand limit. When current flows through a conductor, it creates heat. How well the insulation around a conductor can dissipate that heat depends on factors such as whether that conductor is in free air or not. Think what happens to you if you put on a sweater, a jacket, and then a coat—all at the same time. You heat up. Your skin can't dissipate heat with all that clothing on nearly as well as it dissipates heat in free air. The same principal applies to conductors.

Conductor insulation also fails with age. That's why we conduct cable testing and take other measures to predict failure and replace certain conductors (for example, feeders or critical equipment conductors) while they're still within design specifications. But conductor insulation failure takes decades under normal use—and it's a maintenance issue. However, if a conductor is forced to exceed the ampacity listed in the appropriate table, and as a result its design temperature is exceeded, insulation failure happens much more rapidly—often catastrophically. Exceeding the allowable ampacity is a serious safety issue.

71 310.4 Conductors in Parallel.

(A) General. Ungrounded and neutral conductors sized 1/0 AWG and larger can be connected in parallel.

(B) Conductor Characteristics. When circuit conductors are run in parallel, the current must be evenly distributed between the individual parallel conductors by requiring all circuit conductors within a parallel set to: Figure 310–1

(1) Be the same length.

(2) Be made of the same conductor material (copper/aluminum).

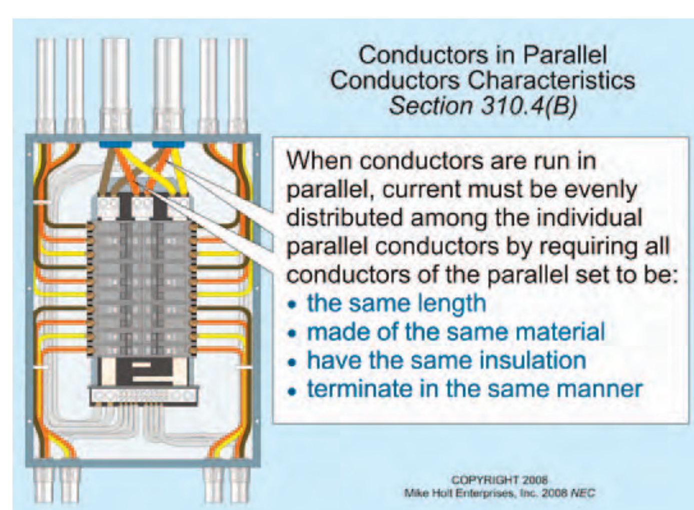

Figure 310–1

(3) Be the same size in circular mil area (minimum 1/0 AWG).

(4) Have the same insulation (like THHN).

(5) Terminate in the same method (set screw versus compression).

Author's Comment: Conductors aren't required to have the same physical characteristics as those of another phase or neutral conductor to achieve balance [310.14(C)].

(C) Separate Raceways or Cables. Raceways or cables containing parallel conductors must have the same electrical characteristics and the same number of conductors. Figure 310–2

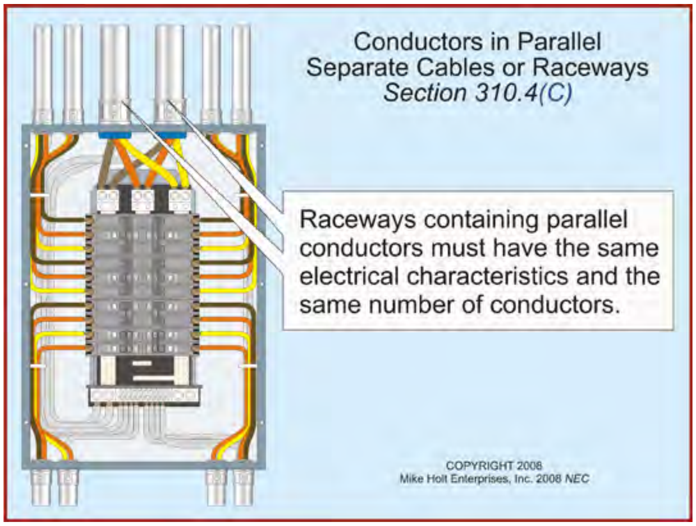

Figure 310–2

Author's Comment: If one set of parallel conductors is run in a metallic raceway and the other conductors are run in PVC conduit, the conductors in the metallic raceway will have an increased opposition to current flow (impedance) as compared to the conductors in the nonmetallic raceway. This results in an unbalanced distribution of current between the parallel conductors.

Paralleling is done in sets. Parallel sets of conductors aren't required to have the same physical characteristics as those of another set to achieve balance.

Author's Comment: For example, a 400A feeder with a neutral load of 240A can be paralleled as follows. Figure 310–3.

- Phase A, Two—250 kcmil THHN aluminum, 100 ft
- Phase B, Two—3/0 THHN copper, 104 ft
- Phase C, Two—3/0 THHN copper, 102 ft

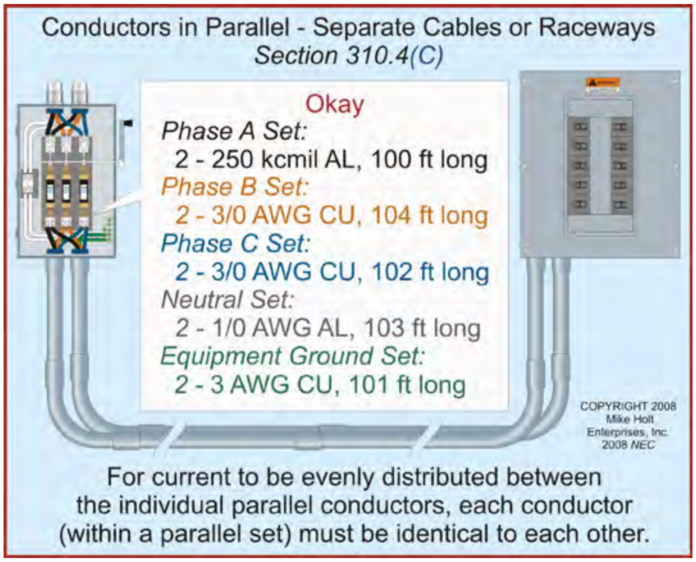

Figure 310–3

- Neutral, Two—1/0 THHN aluminum, 103 ft
- Equipment Grounding Conductor, Two—3 AWG copper, 101 ft*

**The minimum 1/0 AWG size requirement doesn't apply to equipment grounding conductors [310.4(E)].*

(D) Conductor Ampacity Adjustment. Each current-carrying conductor of a paralleled set of conductors must be counted as a current-carrying conductor for the purpose of conductor ampacity adjustment, in accordance with Table 310.15(B)(2)(a). Figure 310–4

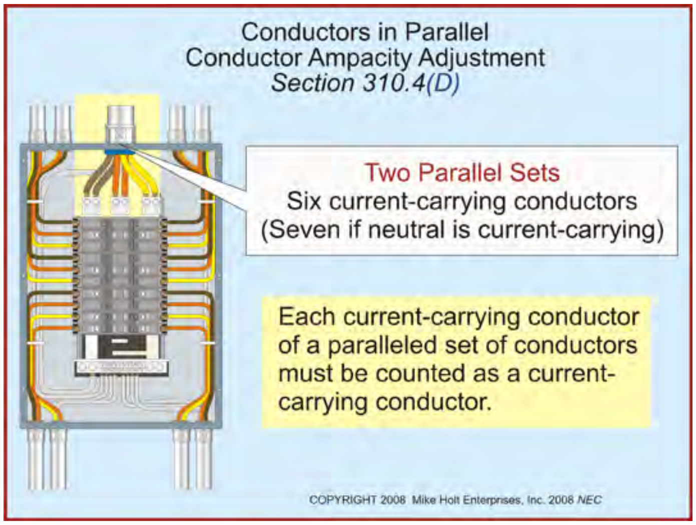

Figure 310–4

(E) Equipment Grounding Conductors. The equipment grounding conductors for circuits in parallel must be identical to each other in length, material, size, insulation, and termination. In addition, each raceway, where required, must have an equipment grounding conductor sized in accordance with 250.122. The minimum 1/0 AWG rule of 310.4 doesn't apply to equipment grounding conductors. See 250.122(F)(1) for more information on equipment grounding conductors installed in parallel. Figure 310–5

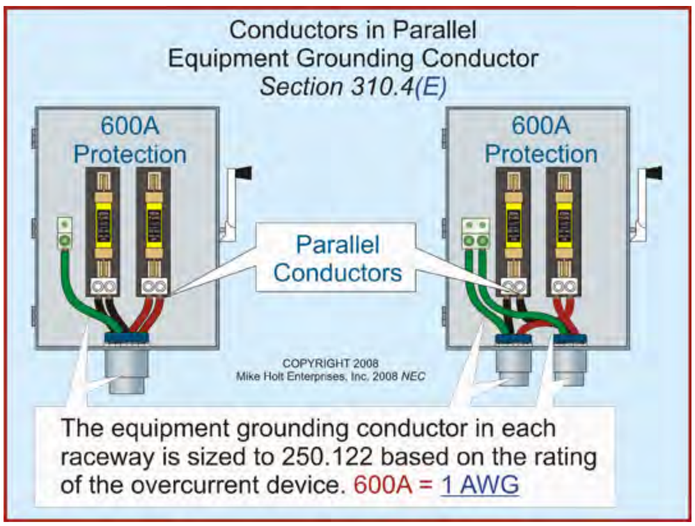

Figure 310–5

310.15 Conductor Ampacity.

(A) General Requirements.

(1) Tables for Engineering Supervision. The ampacity of a conductor can be determined either by using the tables in accordance with 310.15(B), or under engineering supervision as provided in 310.15(C).

> **FPN No. 1:** Ampacities provided by this section don't take voltage drop into consideration. See 210.19(A) FPN No. 4, for branch circuits and 215.2(D) FPN No. 2, for feeders.

(2) Conductor Ampacity—Lower Rating. If a single length of conductor is routed in a manner that two or more ampacity ratings apply to a single conductor length, the lower ampacity must be used for the entire circuit. See 310.15(B). Figure 310–6

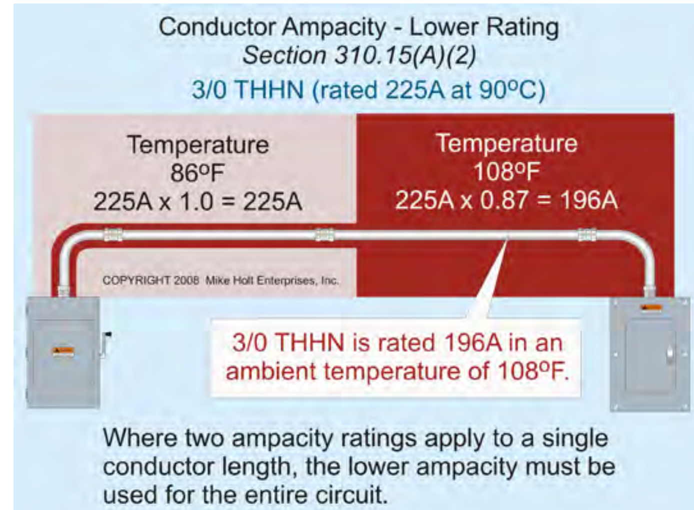

Figure 310–6

Exception: When different ampacities apply to a length of conductor, the higher ampacity is permitted for the entire circuit if the reduced ampacity length doesn't exceed 10 ft and its length doesn't exceed 10 percent of the length of the higher ampacity. Figure 310–7

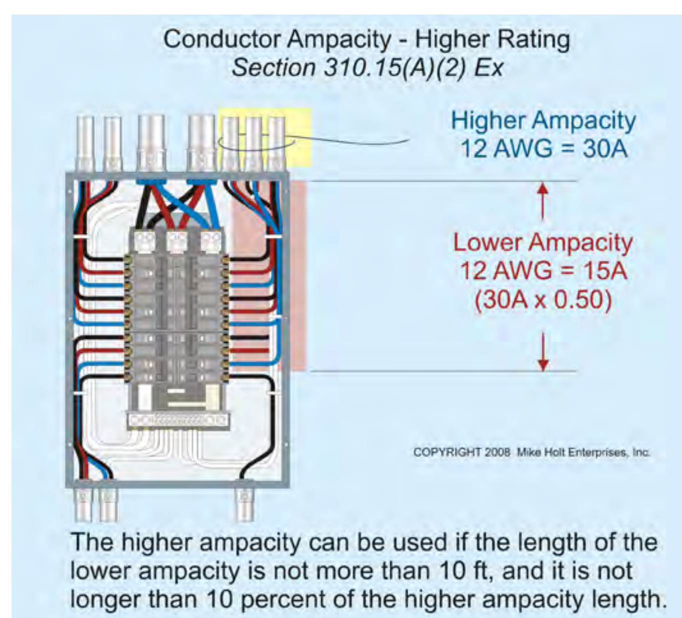

Figure 310–7

(B) Ampacity Table. The allowable conductor ampacities listed in Table 310.16 are based on conditions where the ambient temperature isn't over 86°F, and no more than three current-carrying conductors are bundled together. Figure 310–8

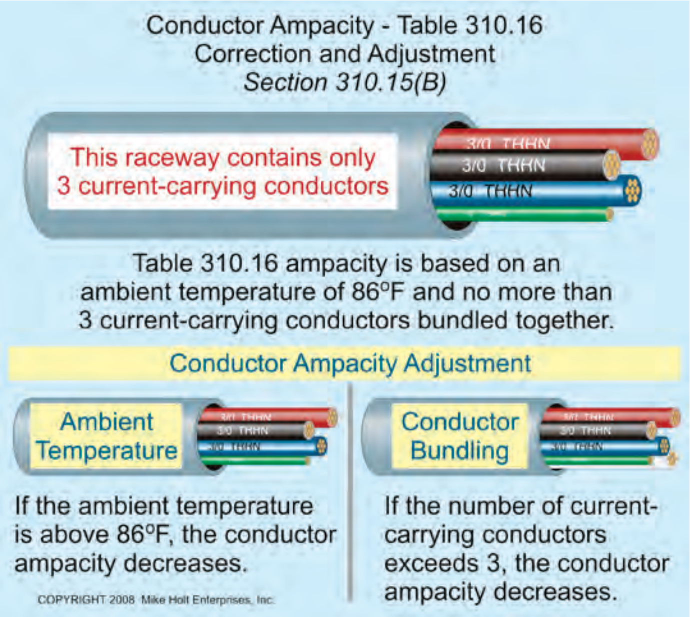

Figure 310–8

Author's Comment: When conductors are installed in an ambient temperature other than 78°F to 86°F, ampacities listed in Table 310.16 must be corrected in accordance with the multipliers listed in Table 310.16.

Table 310.16 Ambient Temperature Correction

Ambient Temperature °F	Ambient Temperature °C	Correction Factor 75°C Conductors	Correction Factor 90°C Conductors
70–77°F	21–25°C	1.05	1.04
78–86°F	26–30°C	1.00	1.00
87–95°F	31–35°C	0.94	0.96
96–104°F	36–40°C	0.88	0.91
105–113°F	41–45°C	0.82	0.87
114–122°F	46–-50°C	0.75	0.82
123–131°F	51–-55°C	0.67	0.76
132–140°F	56–60°C	0.58	0.71
141–158°F	61–70°C	0.33	0.58
159–176°F	71–80°C	0.00	0.41

Author's Comment: When correcting conductor ampacity for elevated ambient temperature, the correction factor used for THHN conductors is based on the 90°C rating of the conductor in a dry location and 75°C rating of the conductor in a wet location, based on the conductor ampacity listed in Table 310.16 [110.14(C) and Table 310.13(A)].

Question: *What is the corrected ampacity of 3/0 THHN/THWN conductors in a dry location if the ambient temperature is 108°F?*

(a) 173A (b) 196A (c) 213A (d) 241A

Answer: *(b) 196A*

Conductor Ampacity [90°C] = 225A
Correction Factor [Table 310.16] = 0.87

Corrected Ampacity = 225A x 0.87
Corrected Ampacity = 196A

Question: *What is the corrected ampacity of 3/0 THHN/THWN conductors in a wet location if the ambient temperature is 108°F?*

(a) 164A (b) 196A (c) 213A (d) 241A

Answer: *(a) 164A*

Conductor Ampacity [75°C] = 200A
Correction Factor [Table 310.16] = 0.82

Corrected Ampacity = 200A x 0.82
Corrected Ampacity = 164A

Author's Comment: When adjusting conductor ampacity, the ampacity is based on the temperature insulation rating of the conductor as listed in Table 310.16, not the temperature rating of the terminal [110.14(C)].

(2) Adjustment Factors.

(a) Conductor Bundle. Where the number of current-carrying conductors in a raceway or cable exceeds three, or where single conductors or multiconductor cables are installed without maintaining spacing for a continuous length longer than 24 in., the allowable ampacity of each conductor, as listed in Table 310.16, must be adjusted in accordance with the adjustment factors contained in Table 310.15(B)(2)(a). Figure 310–9

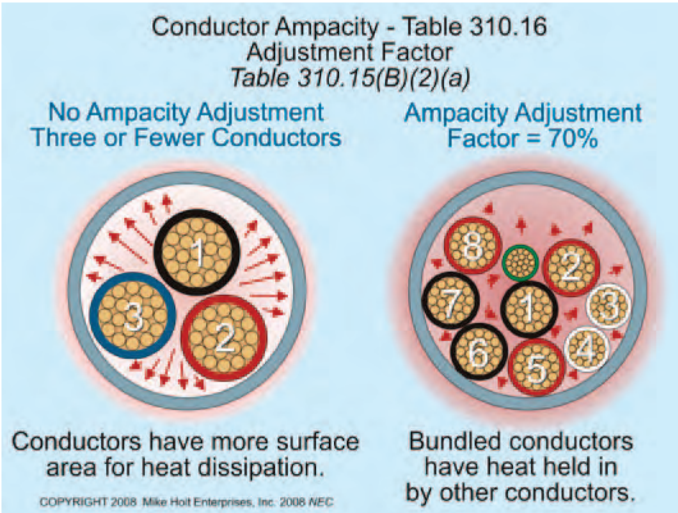

Figure 310–9

Each current-carrying conductor of a paralleled set of conductors must be counted as a current-carrying conductor. Figure 310–10

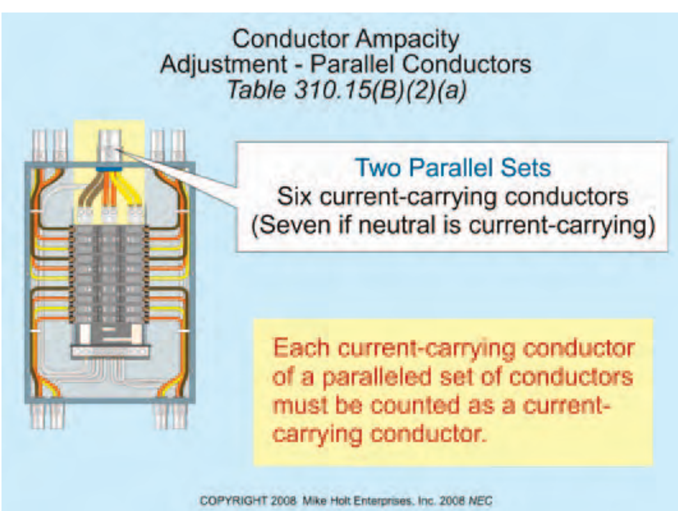

Figure 310–10

Table 310.15(B)(2)(a)	
Number of Current–Carrying	Adjustment Factor
1–3 Conductors	1.00
4–6 Conductors	0.80
7–9 Conductors	0.70*
10–20 Conductors	0.50

Author's Comment: The neutral conductor might be a current-carrying conductor, but only under the conditions specified in 310.15(B)(4). Equipment grounding conductors are never considered current carrying [310.15(B)(5)].

Question: *What is the adjusted ampacity of 3/0 THHN/THWN conductors in a dry location if the raceway contains a total of four current-carrying conductors?* Figure 310–11

(a) 180A *(b) 196A* *(c) 213A* *(d) 241A*

Answer: *(a) 180A*

Table 310.16 ampacity if 3/0 THHN/THWN in a dry location is 225A

Adjustment Factor [Table 310.15(B)(2)(a)] = 0.80

Adjusted Ampacity = 225A x 0.80
Adjusted Ampacity = 180A

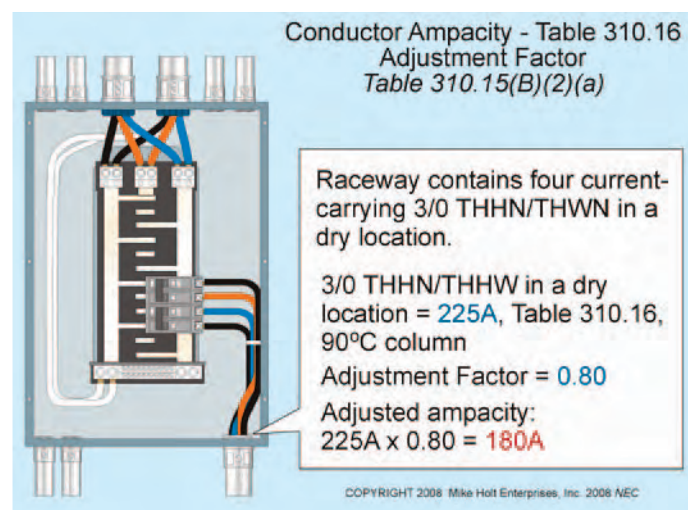

Figure 310–11

Question: *What is the adjusted ampacity of 3/0 THHN/THWN conductors in a wet location if the raceway contains a total of four current-carrying conductors?*

(a) 160A (b) 196A (c) 213A (d) 241A

Answer: *(a) 160A*

Table 310.16 ampacity if 3/0 THHN/THWN in a wet location is 200A

Adjustment Factor [Table 310.15(B)(2)(a)] = 0.80

Adjusted Ampacity = 200A x 0.80
Adjusted Ampacity = 160A

Author's Comments:

- When correcting or adjusting conductor ampacity, the ampacity is based on the temperature insulation rating of the conductor as listed in Table 310.16, not the temperature rating of the terminal [110.14(C)].
- Where more than three current-carrying conductors are present and the ambient temperature isn't between 78 and 86°F, the ampacity listed in Table 310.16 must be corrected and adjusted for both conditions.

Question: *What is the ampacity of 3/0 THHN/THWN conductors in a dry location at an ambient temperature of 108°F if the raceway contains four current-carrying conductors?*

(a) 157A (b) 176A (c) 199A (d) 214A

Answer: *(a) 157A*

Table 310.16 ampacity if 3/0 THHN/THWN in a dry location is 225A

Ambient Temperature Correction [Table 310.16] = 0.87
Conductor Bundle Adjustment [310.15(B)(2)(a)] = 0.80
Adjusted Ampacity = 225A x 0.87 x 0.80
Adjusted Ampacity = 157A

Author's Comment: When adjusting or correcting conductor ampacity, the ampacity of THHN/THWN conductors in a dry location is based on the 90°C rating of the conductor [110.14(C) and Table 310.13(A)].

Question: *What is the ampacity of 3/0 THHN/THWN conductors in a wet location at an ambient temperature of 108°F if the raceway contains four current-carrying conductors?*

(a) 131A (b) 176A (c) 199A (d) 214A

Answer: *(a) 131A*

Table 310.16 ampacity if 3/0 THHN/THWN in a wet location is 200A

Ambient Temperature Correction [Table 310.16] = 0.82

Conductor Bundle Adjustment [310.15(B)(2)(a)] = 0.80

Adjusted Ampacity = 200A x 0.82 x 0.80
Adjusted Ampacity = 131.20A

Author's Comment: When adjusting or correcting conductor ampacity, the ampacity of THHN/THWN conductors in a wet location is based on the 75°C rating of the conductor [110.14(C) and Table 310.13(A)].

FPN No. 2: See 376.22(B) for conductor ampacity adjustment factors for conductors in metal wireways.

Author's Comment: Conductor ampacity adjustment only applies when more than 30 current-carrying conductors are installed in any cross-sectional area of a metal wireway.

Exception No. 3: The conductor ampacity adjustment factors of Table 310.15(B)(2)(a) don't apply to conductors installed in raceways not exceeding 24 in. in length. Figure 310–12

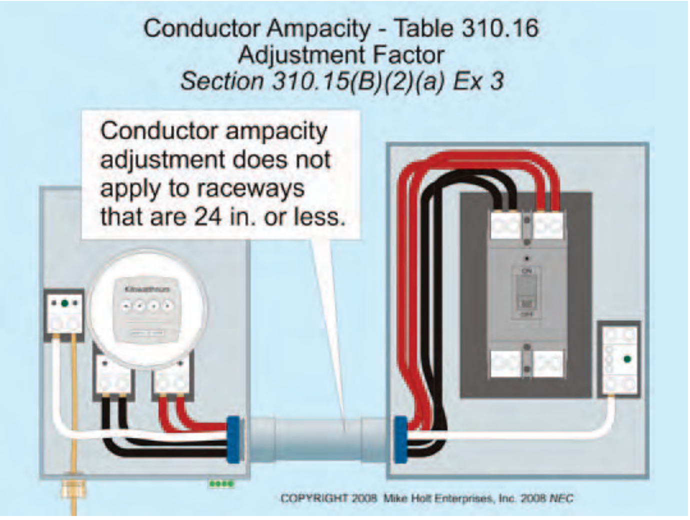

Figure 310–12

Exception No. 5: The conductor ampacity adjustment factors of Table 310.15(B)(2)(a) don't apply to Type AC or Type MC cable when: Figure 310–13

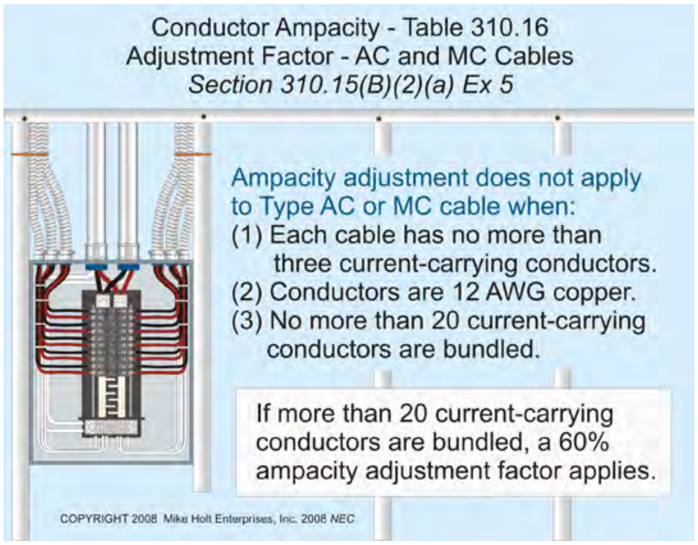

Figure 310–13

(1) Each cable has not more than three current-carrying conductors,

(2) The conductors are 12 AWG copper, and

(3) No more than 20 current-carrying conductors (ten 2-wire cables or six 3-wire cables) are bundled.

Author's Comment: When eleven or more 2-wire cables or seven or more 3-wire cables (more than 20 current-carrying conductors) are bundled or stacked for more than 24 in., an ampacity adjustment factor of 60 percent must be applied.

(c) Raceways Exposed to Sunlight on Rooftops. The ambient temperature adjustment contained in Table 310.15(B)(2)(c) is added to the outdoor ambient temperature for conductors or cables that are installed in raceways exposed to direct sunlight on or above rooftops when applying ampacity adjustment correction factors contained in Table 310.16.

FPN No. 1: See ASHRAE Handbook—*Fundamentals* (www.ashrae.org) as a source for the average ambient temperatures in various locations.

FPN No. 2: The temperature adders in Table 310.15(B)(2)(c) are based on the results of averaging the ambient temperatures.

Table 310.15(B)(2)(c) Ambient Temperature Adder for Raceways On or Above Rooftops

Distance of Raceway Above Roof	C°	F°
0 to ½ in.	33	60
Above ½ in. to 3 ½ in.	22	40
Above 3 ½ in. to 12 in.	17	30
Above 12 in. to 36 in.	14	25

Author's Comment: This section requires the ambient temperature used for ampacity correction to be adjusted where conductors or cables are installed in conduit on or above a rooftop and the conduit is exposed to direct sunlight. The reasoning is that the air inside conduits in direct sunlight is significantly hotter than the surrounding air, and appropriate ampacity corrections must be made in order to comply with 310.10.

For example, a conduit with three 6 THWN-2 conductors with direct sunlight exposure that is ¾ in. above the roof will require 40°F to be added to the correction factors at the bottom of Table 310.16. Assuming an ambient temperature of 90°F, the temperature to use for conductor correction will be 130°F (90°F + 40°F), the 6 THWN-2 conductor ampacity after correction will be 57A (75A x 0.76). Figure 310–14

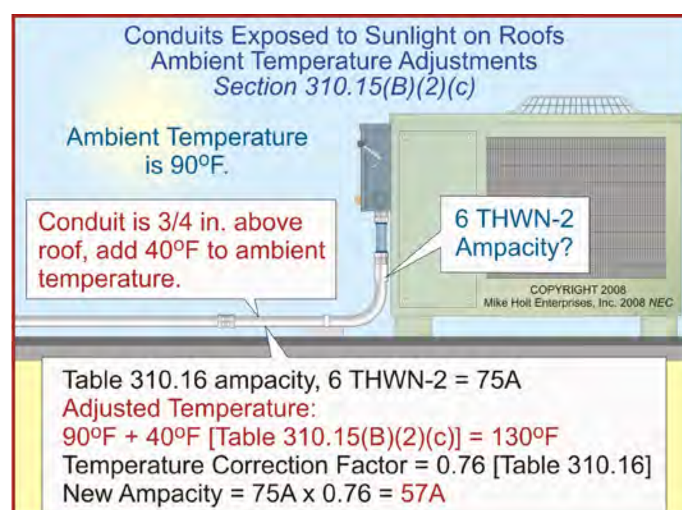

Figure 310–14

When adjusting conductor ampacity, use the conductor ampacity as listed in Table 310.16 based on the conductors' insulation rating; in this case, it's 75A at 90°F. Conductor ampacity adjustment is not based on the temperature terminal rating as per 110.14(C).

(4) Neutral Conductors.

(a) Balanced Circuits. The neutral conductor of a 3-wire, single-phase, 120/240V system, or 4-wire, three-phase, 120/208V or 277/480V wye-connected system, isn't considered a current-carrying conductor. Figure 310–15

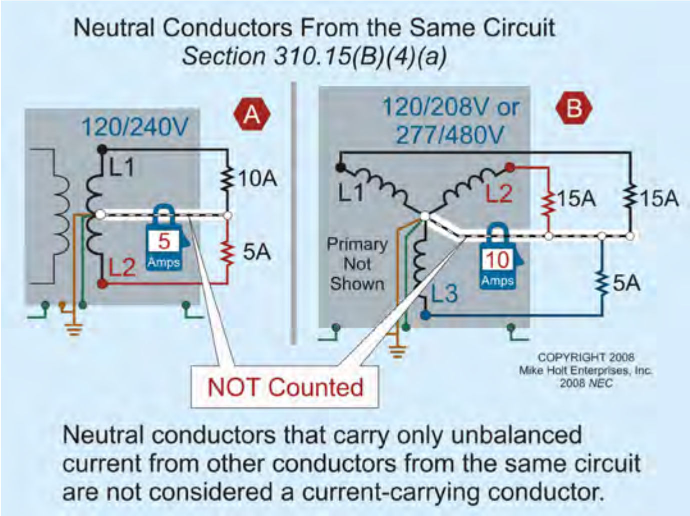

Figure 310–15

(b) 3-Wire Circuits. The neutral conductor of a 3-wire circuit from a 4-wire, three-phase, 120/208V or 277/480V wye-connected system is considered a current-carrying conductor.

> **Author's Comment:** When a 3-wire circuit is supplied from a 4-wire, three-phase, 120/208V or 277/480V wye-connected system, the neutral conductor carries approximately the same current as the ungrounded conductors. Figure 310–16

(c) Wye 4-Wire Circuits That Supply Nonlinear Loads. The neutral conductor of a 4-wire, three-phase, 120/208V or 277/480V wye-connected system is considered a current-carrying conductor where more than 50 percent of the neutral load consists of nonlinear loads. This is because harmonic currents will be present in the neutral conductor, even if the loads on each of the three phases are balanced. Figure 310–17

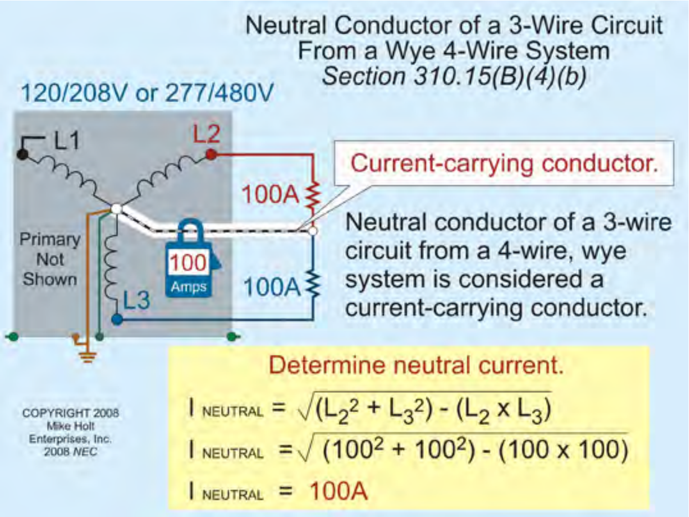

Figure 310–16

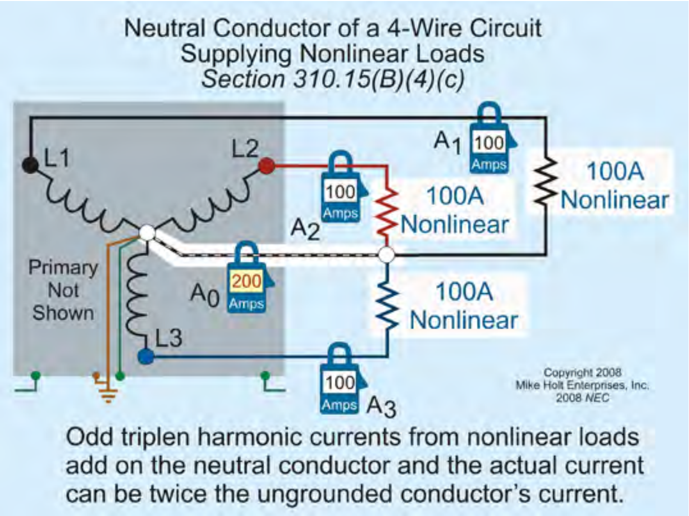

Figure 310–17

> **Author's Comment:** Nonlinear loads supplied by a 4-wire, three-phase, 120/208V or 277/480V wye-connected system can produce unwanted and potentially hazardous odd triplen harmonic currents (3rd, 9th, 15th, etc.) that can add on the neutral conductor. To prevent fire or equipment damage from excessive harmonic neutral current, the designer should consider increasing the size of the neutral conductor or installing a separate neutral for each phase. For more information, visit www.MikeHolt.com, click on the 'Technical' link, then the 'Power Quality' link. Also see 210.4(A) FPN, 220.61 FPN No. 2, and 450.3 FPN No. 2.

(5) Grounding Conductors. Grounding and bonding conductors aren't considered current carrying.

(6) Dwelling Unit Feeder/Service Conductors. For individual dwelling units of one-family, two-family, and multifamily dwellings, Table 310.15(B)(6) can be used to size 3-wire, single-phase, 120/240V service or feeder conductors that supply all loads that are part of, or associated with, the dwelling unit. Figure 310–18

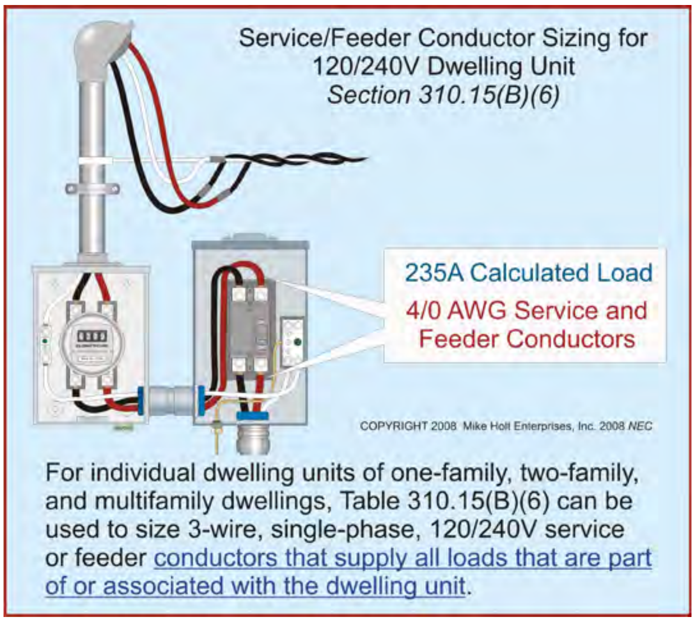

Figure 310–18

Author's Comment: Table 310.15(B)(6) cannot be used for service conductors for two-family or multifamily buildings. Figure 310–19

Feeder conductors are not required to have an ampacity rating more than the service conductors [215.2(A)(3)].

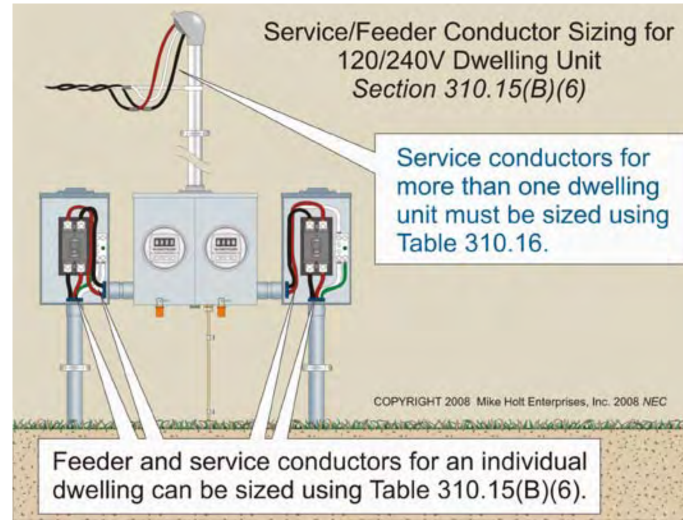

Figure 310–19

Table 310.15(B)(6) Conductor Sizes for 120/240V, 3-Wire, Single-Phase Dwelling Services and Feeders

Amperes	Copper	Aluminum
100	4 AWG	2 AWG
110	3 AWG	1 AWG
125	2 AWG	1/0 AWG
150	1 AWG	2/0 AWG
175	1/0 AWG	3/0 AWG
200	2/0 AWG	4/0 AWG
225	3/0 AWG	250 kcmil
250	4/0 AWG	300 kcmil
300	250 kcmil	350 kcmil
350	350 kcmil	500 kcmil
400	400 kcmil	600 kcmil

WARNING: *Table 310.15(B)(6) doesn't apply to 3-wire feeder/service conductors connected to a three-phase, 120/208V system, because the neutral conductor in these systems always carries neutral current, even when the load on the phases is balanced [310.15(B)(4)(b)]. For more information on this topic, see 220.61(C)(1).* Figure 310–20

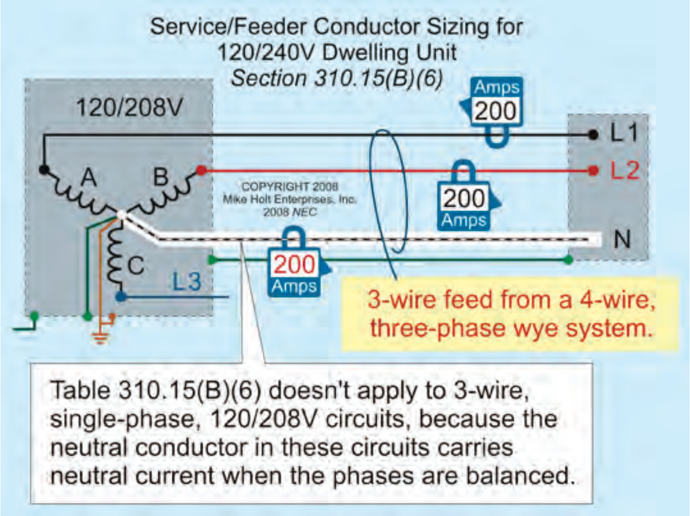

Figure 310–20

Neutral Conductor Sizing. Table 310.15(B)(6) can be used to size the neutral conductor of a 3-wire, single-phase, 120/240V service or feeder that carries all loads associated with the dwelling unit, based on the calculated load in accordance with 220.61.

> **CAUTION:** *Because the service neutral conductor is required to serve as the effective ground-fault current path, it must be sized so it can safely carry the maximum fault current likely to be imposed on it [110.10 and 250.4(A)(5)]. This is accomplished by sizing the neutral conductor in accordance with Table 250.66, based on the area of the largest ungrounded service conductor [250.24(C)(1)].*

Question: *What size service conductors are required if the calculated load for a dwelling unit equals 195A, and the maximum unbalanced neutral load is 100A?* Figure 310–21

(a) 1/0 AWG and 6 AWG *(b) 2/0 AWG and 4 AWG*
(c) 3/0 AWG and 2 AWG *(d) 4/0 AWG and 1 AWG*

Answer: *(b) 2/0 AWG and 4 AWG*

Service Conductor: 2/0 AWG rated 200A [Table 310.15(B)(6)]

Neutral Conductor: 4 AWG is rated 100A in accordance with Table 310.15(B)(6). In addition, 250.24(C) requires the neutral conductor to be sized no smaller than 4 AWG based on 2/0 AWG service conductors in accordance with Table 250.66.

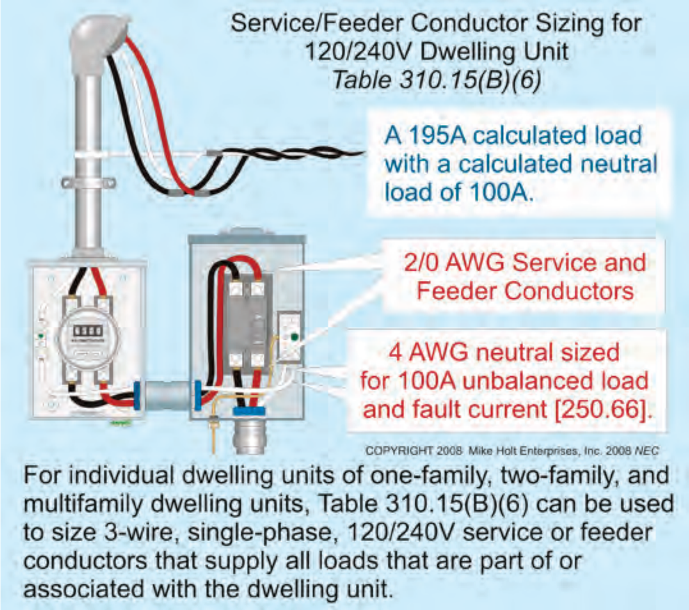

Figure 310–21

ARTICLE

312 Cabinets, Cutout Boxes, and Meter Socket Enclosures

INTRODUCTION TO ARTICLE 312—CABINETS, CUTOUT BOXES, AND METER SOCKET ENCLOSURES

This article addresses the installation and construction specifications for the items mentioned in its title. In Article 310, we observed that you need different ampacities for the same conductor, depending on conditions of use. The same thing applies to these items—just in a different way. For example, you can't use just any enclosure in a wet location or in a hazardous (classified) location. The conditions of use impose special requirements for these situations.

For all such enclosures, certain requirements apply—regardless of the use. For example, you must cover any openings, protect conductors from abrasion, and allow sufficient bending room for conductors.

Part I is where you'll find the requirements most useful to the electrician in the field. Part II applies to manufacturers. If you use name brand components that are listed or labeled, you don't need to be concerned with Part II. However, if you are specifying custom enclosures, you need to be familiar with these requirements to help ensure that the authority having jurisdiction approves the enclosures.

73 **312.8 Used for Raceway and Splices.** Cabinets, cutout boxes, and meter socket enclosures can be used as a raceway for conductors that feed through if the conductors don't fill the wiring space at any cross section to more than 40 percent. Figure 312–1

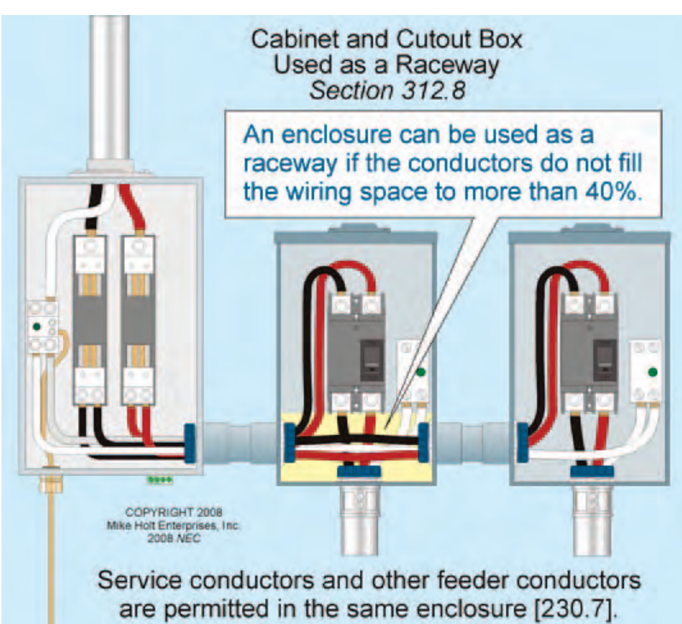

Figure 312–1

Author's Comment: Service conductors and other conductors can be installed in the same enclosure [230.7].

Splices and taps can be installed in cabinets, cutout boxes, or meter socket enclosures if the splices or taps don't fill the wiring space at any cross section to more than 75 percent. Figure 312–2

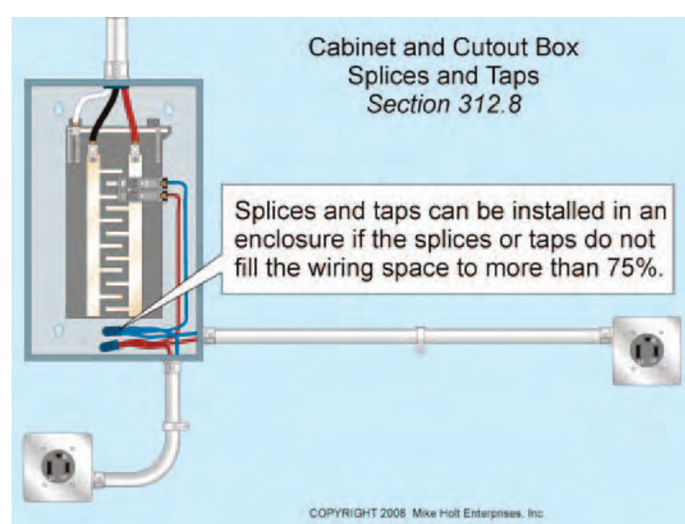

Figure 312–2

ARTICLE 314 Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; and Handhole Enclosures

INTRODUCTION TO ARTICLE 314—OUTLET, DEVICE, PULL, AND JUNCTION BOXES; CONDUIT BODIES; AND HANDHOLE ENCLOSURES

Article 314 contains installation requirements for outlet boxes, pull and junction boxes, conduit bodies, and handhole enclosures.

As with Article 312, conditions of use apply. If you're running a raceway in a hazardous (classified) location, for example, you must use the correct fittings and the proper installation methods. But consider something as simple as a splice. It makes sense you wouldn't put a splice in the middle of a raceway—doing so means you can't get to it. But if you put a splice in a conduit body, you're fine, right? Not necessarily. Suppose the conduit body is a "short radius" version (think of it as an elbow with the bend chopped off). You don't have much room inside such an enclosure, and for that reason you can't put a splice inside a short-radius conduit body.

Properly applying Article 314 means you'll need to account for the internal volume of all boxes and fittings, and then determine the maximum conductor fill. You'll also need to understand many other requirements, which we'll cover. If you start to get confused, take a break. Look carefully at the illustrations, and you'll learn more quickly and with more retention.

74 314.16 Number of 6 AWG and Smaller Conductors in Boxes and Conduit Bodies.

Boxes containing 6 AWG and smaller conductors must be sized to provide sufficient free space for all conductors, devices, and fittings. In no case can the volume of the box, as calculated in 314.16(A), be less than the volume requirement as calculated in 314.16(B).

Conduit bodies must be sized according to 314.16(C).

Author's Comment: The requirements for sizing boxes and conduit bodies containing conductors 4 AWG and larger are contained in 314.28. The requirements for sizing handhole enclosures are contained in 314.30(A).

(A) Box Volume Calculations. The volume of a box includes the total volume of its assembled parts, including plaster rings, extension rings, and domed covers that are either marked with their volume in cubic inches (cu in.), or are made from boxes listed in Table 314.16(A). Figure 314–1

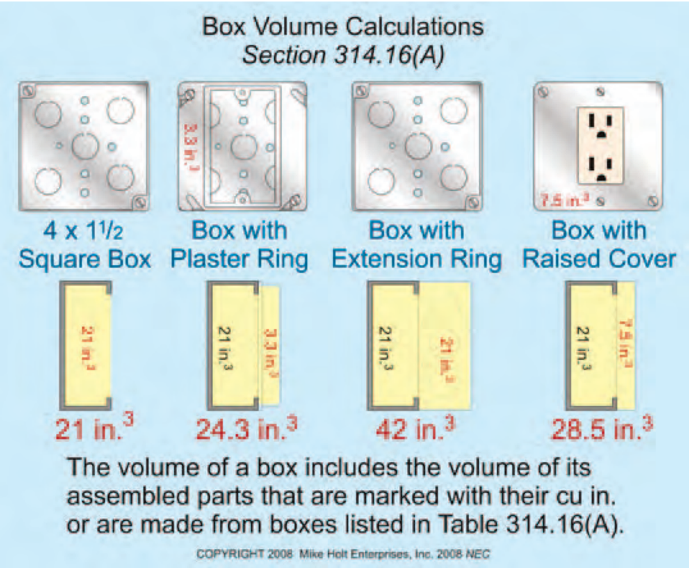

Figure 314–1

(B) Box Fill Calculations. The calculated conductor volume determined by (1) through (5) and Table 314.16(B) are added together to determine the total volume of the conductors, devices, and fittings. Raceway and cable fittings, including locknuts and bushings, are not counted for box fill calculations. Figure 314–2

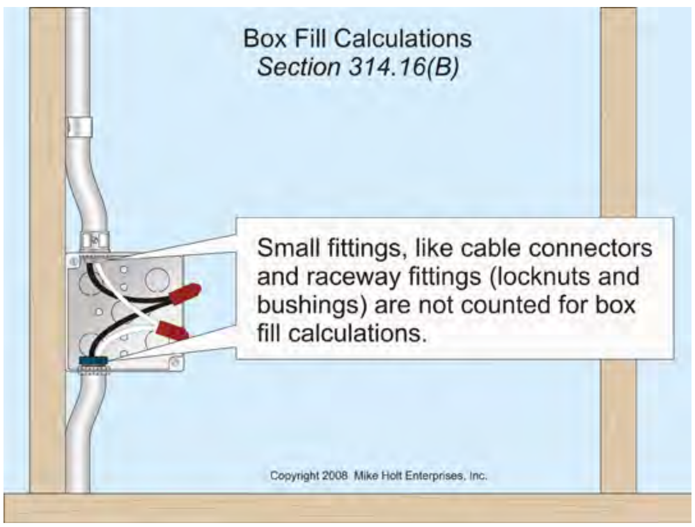

Figure 314–2

Table 314.16(B) Volume Allowance Required per Conductor	
Conductor AWG	Volume cu in.
18	1.50
16	1.75
14	2.00
12	2.25
10	2.50
8	3.00
6	5.00

(1) Conductor Volume. Each unbroken conductor that runs through a box, and each conductor that terminates in a box, is counted as a single conductor volume in accordance with Table 314.16(B). Figure 314–3

Each loop or coil of unbroken conductor having a length of at least twice the minimum length required for free conductors in 300.14 must be counted as two conductor volumes.

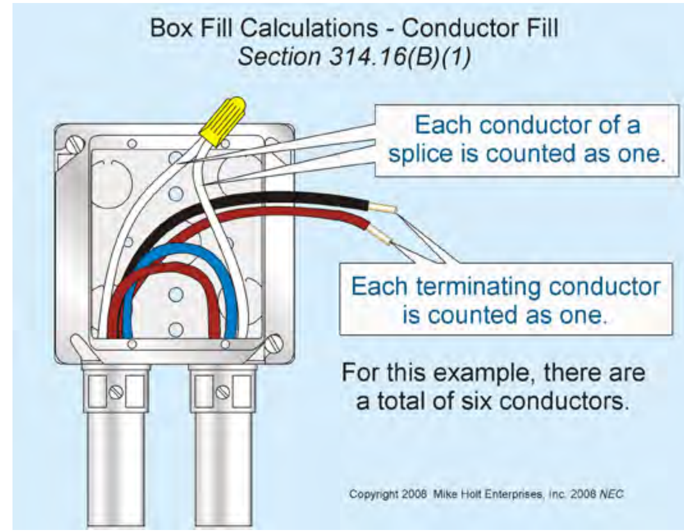

Figure 314–3

Conductors that originate and terminate within the box, such as pigtails, aren't counted at all. Figure 314–4

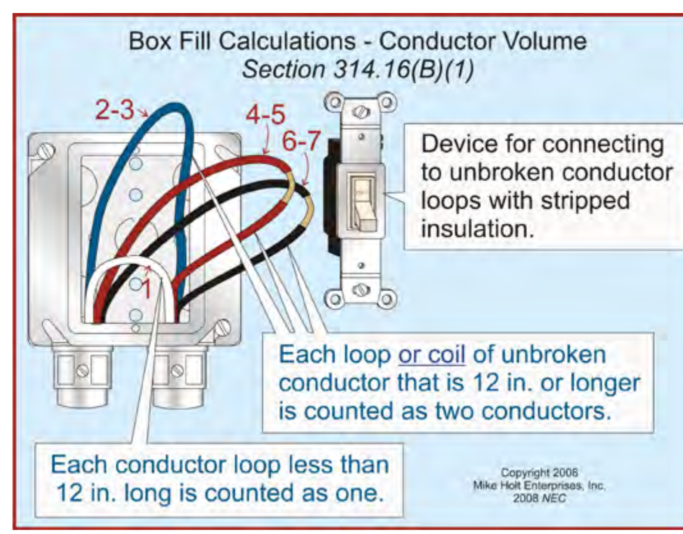

Figure 314–4

Author's Comment: According to 300.14, at least 6 in. of free conductor, measured from the point in the box where the conductors enter the enclosure, must be left at each outlet, junction, and switch point for splices or terminations of luminaires or devices.

Exception: Equipment grounding conductors, and up to four 16 AWG and smaller fixture wires, can be omitted from box fill calculations if they enter the box from a domed luminaire or similar canopy, such as a ceiling paddle fan canopy. Figure 314–5

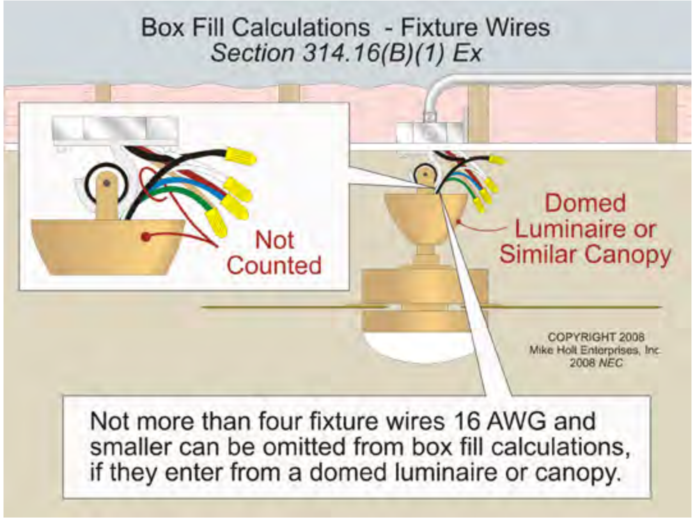

Figure 314–5

(2) Cable Clamp Volume. One or more internal cable clamps count as a single conductor volume in accordance with Table 314.16(B), based on the largest conductor that enters the box. Cable connectors that have their clamping mechanism outside of the box aren't counted. Figure 314–6

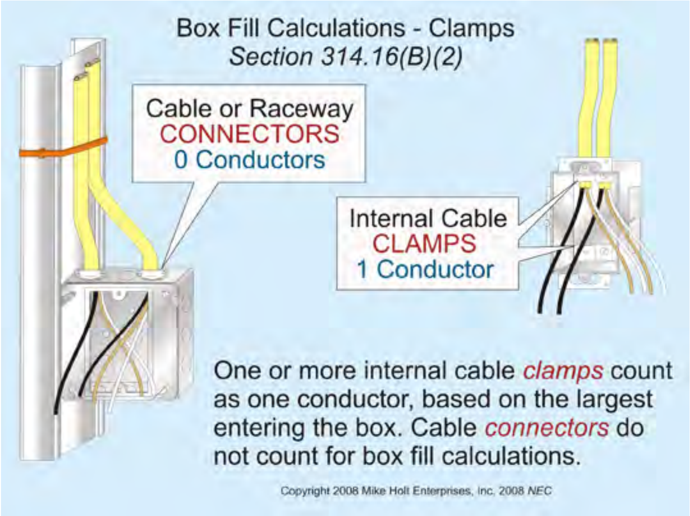

Figure 314–6

(3) Support Fitting Volume. Each luminaire stud or luminaire hickey counts as a single conductor volume in accordance with Table 314.16(B), based on the largest conductor that enters the box. Figure 314–7

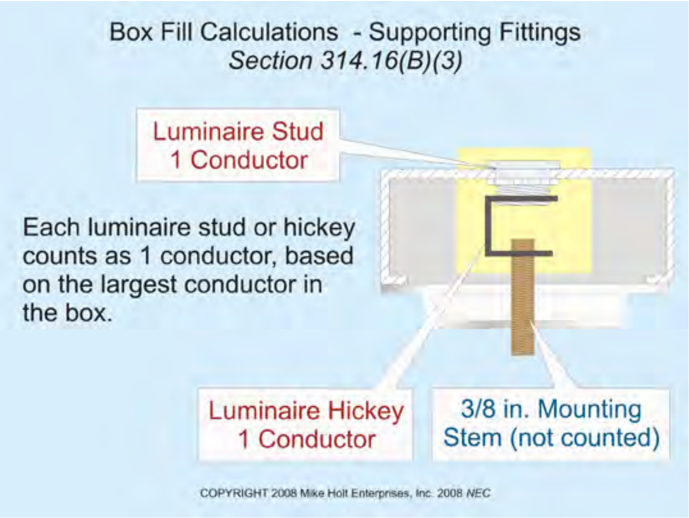

Figure 314–7

Author's Comment: Luminaire stems do not need to be counted as a conductor volume.

(4) Device Yoke Volume. Each single gang device yoke (regardless of the ampere rating of the device) counts as two conductor volumes, based on the largest conductor that terminates on the device in accordance with Table 314.16(B). Figure 314–8

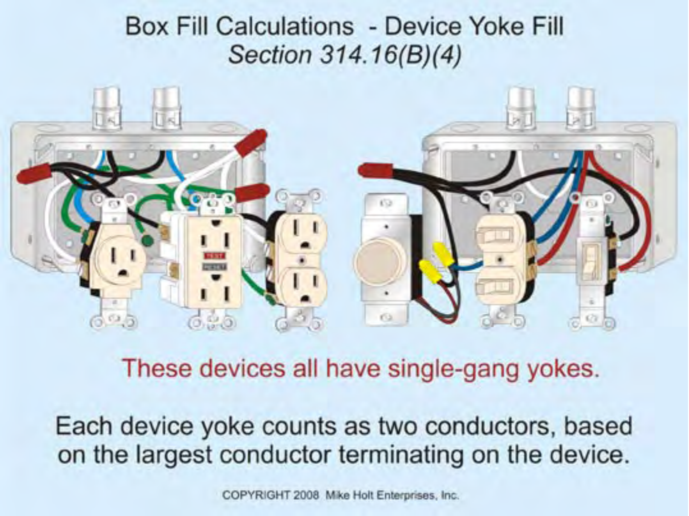

Figure 314–8

Each multigang device yoke counts as two conductor volumes for each gang, based on the largest conductor that terminates on the device in accordance with Table 314.16(B). Figure 314–9

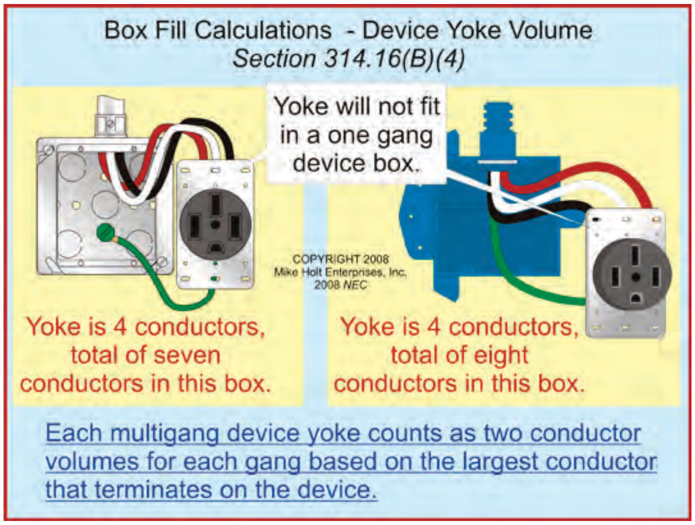

Figure 314–9

Author's Comment: A device that is too wide for mounting in a single gang box, as described in Table 314.16(A), is counted based on the number of gangs required for the device.

(5) Equipment Grounding Conductor Volume. All equipment grounding conductors in a box count as a single conductor volume in accordance with Table 314.16(B), based on the largest equipment grounding conductor that enters the box. Insulated equipment grounding conductors for receptacles having insulated grounding terminals (isolated ground receptacles) [250.146(D)] count as a single conductor volume in accordance with Table 314.16(B). Figure 314–10

Author's Comment: Conductor insulation is not a factor considered when determining box volume calculations.

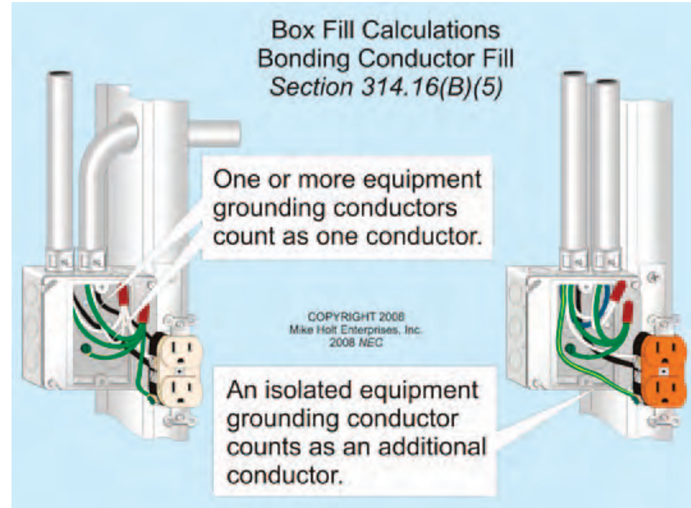

Figure 314–10

Question: *How many 14 AWG conductors can be pulled through a 4 in. square x 2 1/8 in. deep box with a plaster ring with a marking of 3.60 cu in.? The box contains two receptacles, five 12 AWG conductors, and two 12 AWG equipment grounding conductors.* Figure 314–11

(a) 3 (b) 5 (c) 7 (d) 9

Answer: *(b) 5*

Step 1: Determine the volume of the box assembly [314.16(A)]:

Box 30.30 cu in. + 3.60 cu in. plaster ring = 33.90 cu in.

A 4 x 4 x 2 1/8 in. box will have a gross volume of 34 cu in., but the interior volume is 30.30 cu in., as listed in Table 314.16(A).

Step 2: Determine the volume of the devices and conductors in the box:

Two—receptacles	*4—12 AWG*
Five—12 AWG	*5—12 AWG*
Two—12 AWG Grounds	*1—12 AWG*

Total 10—12 AWG x 2.25 cu in. = 22.50 cu in.

Step 3: Determine the remaining volume permitted for the 14 AWG conductors:

33.90 cu in.—22.50 cu in. = 11.40 cu in.

Step 4: Determine the number of 14 AWG conductors permitted in the remaining volume:

14 AWG = 2.00 cu in. each [Table 314.16(B)]
11.40 cu in./2.00 cu in. = 5 conductors

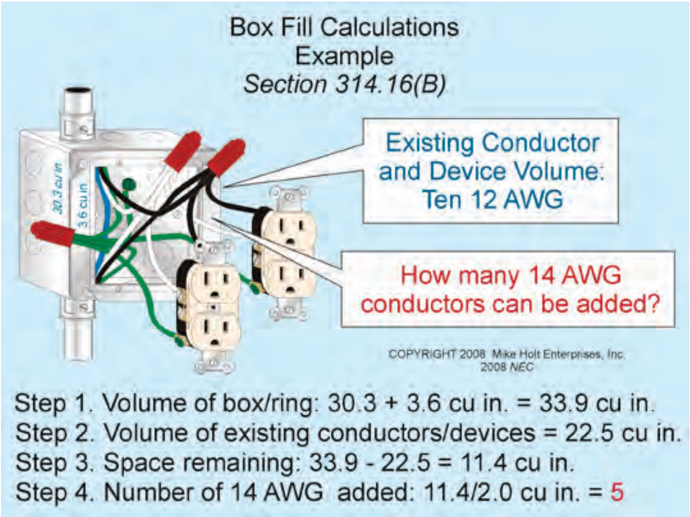

Figure 314–11

(C) Conduit Bodies.

(2) Splices. Splices are only permitted in conduit bodies that are legibly marked, by the manufacturer, with their volume. The maximum number of conductors permitted in a conduit body is limited in accordance with 314.16(B).

Question: *How many 12 AWG conductors can be spliced in a 15 cu in. conduit body?* Figure 314–12

(a) 4 *(b) 6* *(c) 8* *(d) 10*

Answer: *(b) 6 conductors (15 cu in./2.25 cu in.)*

12 AWG = 2.25 cu in. [Table 314.16(B)]
15 cu in./2.25 cu in. = 6

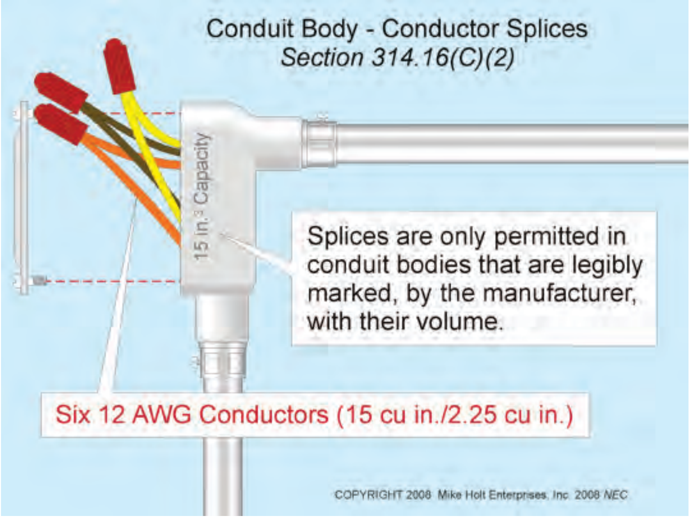

Figure 314–12

75 314.23 Support of Boxes and Conduit Bodies.

Boxes must be securely supported by one of the following methods:

(A) Surface. Boxes can be fastened to any surface that provides adequate support.

(B) Structural Mounting. Boxes can be supported from a structural member of a building or supported from grade by a metal, plastic, or wood brace.

(1) Nails and Screws. Nails or screws can be used to fasten boxes, provided the exposed threads of screws are protected to prevent abrasion of conductor insulation.

(2) Braces. Metal braces no less than 0.020 in. thick and wood braces not less than a nominal 1 x 2 in. can support a box.

(C) Finished Surface Support. Boxes can be secured to a finished surface (drywall or plaster walls or ceilings) by clamps, anchors, or fittings identified for the purpose. Figure 314–13

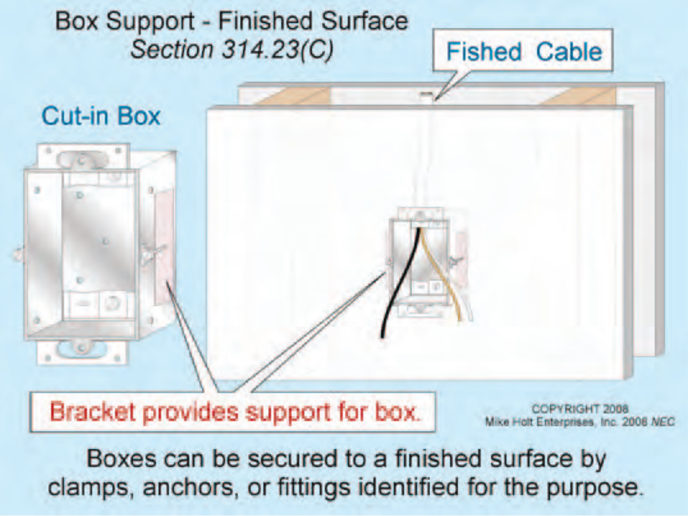

Figure 314–13

(D) Suspended-Ceiling Support. Outlet boxes can be supported to the structural or supporting elements of a suspended ceiling, if securely fastened by one of the following methods:

(1) Ceiling-Framing Members. An outlet box can be secured to suspended-ceiling framing members by bolts, screws, rivets, clips, or other means identified for the suspended-ceiling framing member(s). Figure 314–14

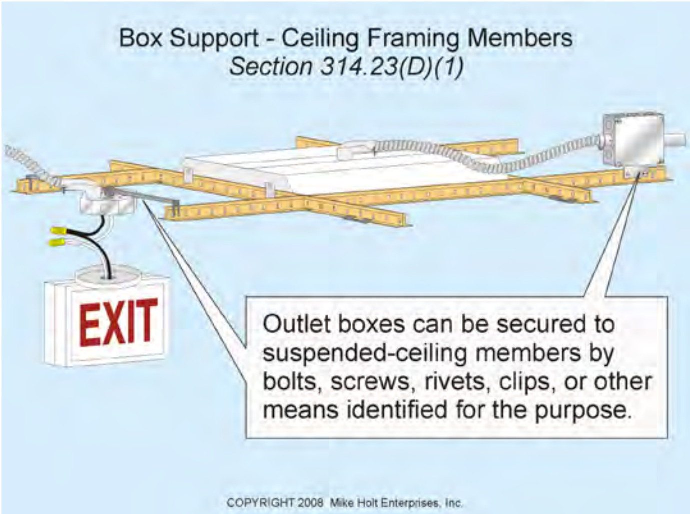

Figure 314–14

Author's Comment: Where framing members of suspended ceiling systems are used to support luminaires, they must be securely fastened to each other and must be securely attached to the building structure at appropriate intervals. In addition, luminaires must be attached to the suspended-ceiling framing members with screws, bolts, rivets, or clips listed and identified for such use [410.36(B)].

(2) Independent Support Wires. Outlet boxes can be secured, with fittings identified for the purpose, to the ceiling support wires. Where independent support wires are used for outlet box support, they must be taut and secured at both ends [300.11(A)]. Figure 314–15

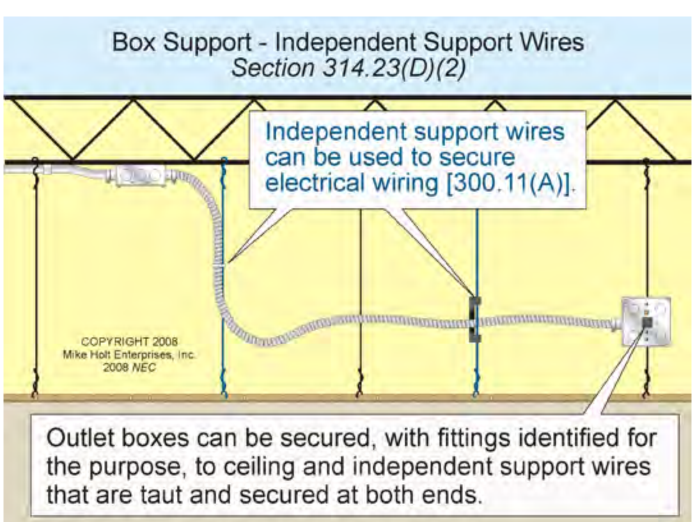

Figure 314–15

Author's Comment: See 300.11(A) on the use of independent support wires to support raceways and cables.

(E) Raceway—Boxes and Conduit Bodies Without Devices or Luminaires. Two intermediate metal or rigid metal conduits, threaded wrenchtight into the enclosure, can be used to support an outlet box that doesn't contain a device or luminaire, if each raceway is supported within 36 in. of the box or within 18 in. if all conduit entries are on the same side. Figure 314–16

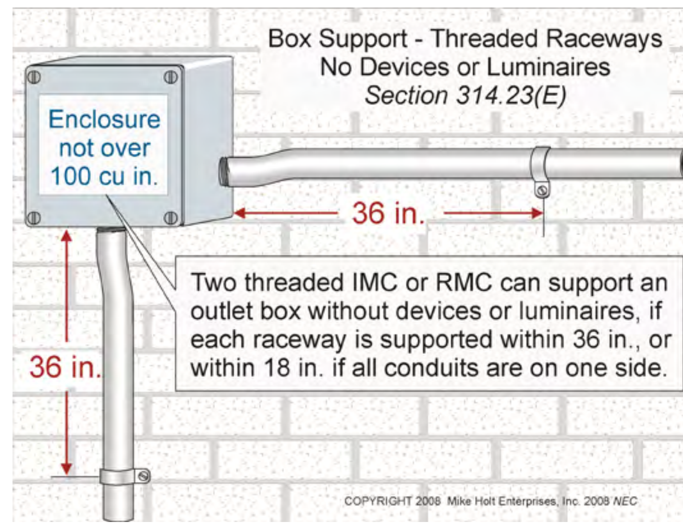

Figure 314–16

(F) Raceway—Boxes and Conduit Bodies with Devices or Luminaires. Two intermediate metal or rigid metal conduits, threaded wrenchtight into the enclosure, can be used to support an outlet box containing devices or luminaires, if each raceway is supported within 18 in. of the box. Figure 314–17

(H) Pendant Boxes.

(1) Flexible Cord. Boxes containing a hub can be supported from a cord connected to fittings that prevent tension from being transmitted to joints or terminals [400.10]. Figure 314–18

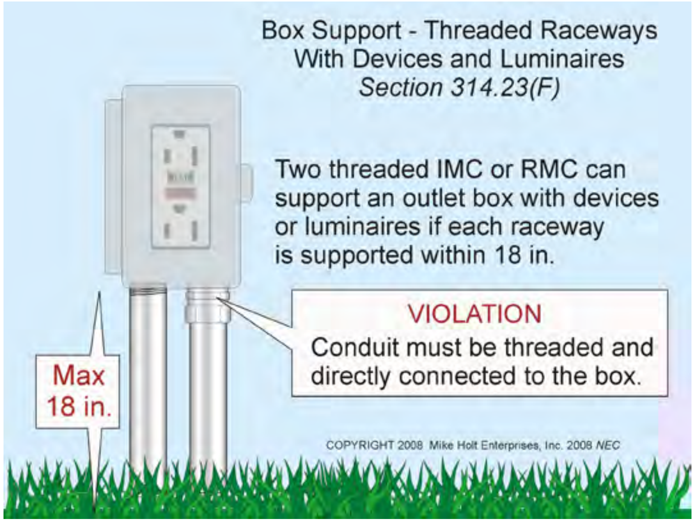

Figure 314–17

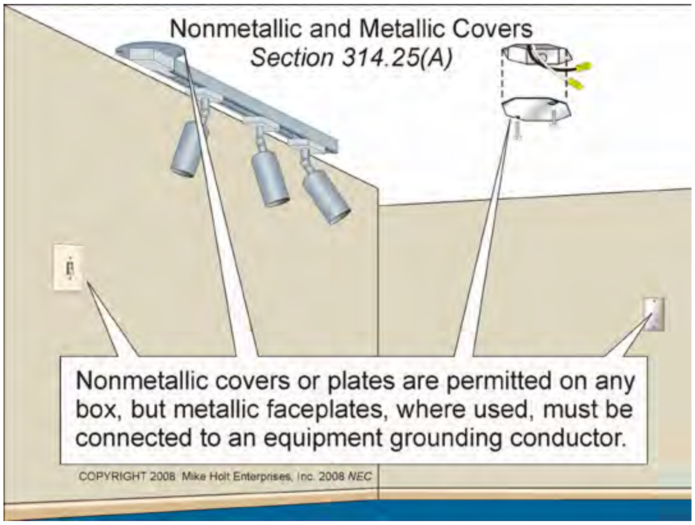

Figure 314–19

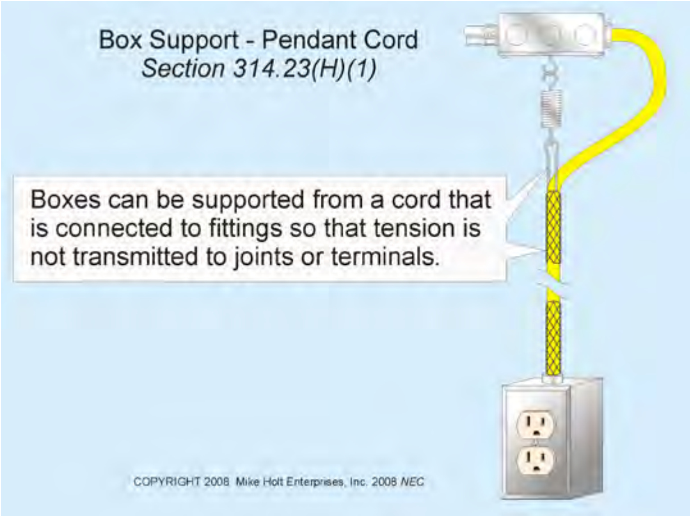

Figure 314–18

76 **314.25 Covers and Canopies.** When the installation is complete, each outlet box must be provided with a cover or faceplate, unless covered by a fixture canopy, lampholder, or similar device. Figure 314–19

(A) Nonmetallic or Metallic. Nonmetallic covers are permitted on any box, but metal covers are only permitted where they can be connected to an equipment grounding conductor of a type recognized in 250.118, in accordance with 250.110 [250.4(A)(3)].

Author's Comment: Metal switch faceplates [404.9(B)] and metal receptacle faceplates [406.5(A)] must be connected to an equipment grounding conductor.

77 **314.28 Boxes and Conduit Bodies for Conductors 4 AWG and Larger.** Boxes and conduit bodies containing conductors 4 AWG and larger that are required to be insulated must be sized so the conductor insulation will not be damaged.

Author's Comments:

- The requirements for sizing boxes and conduit bodies containing conductors 6 AWG and smaller are contained in 314.16.
- Where conductors 4 AWG or larger enter a box or other enclosure, a fitting that provides a smooth, rounded, insulating surface, such as a bushing or adapter, is required to protect the conductors from abrasion during and after installation [300.4(G)].

(A) Minimum Size. For raceways containing conductors 4 AWG or larger, the minimum dimensions of boxes and conduit bodies must comply with the following:

(1) Straight Pulls. The minimum distance from where the conductors enter to the opposite wall must not be less than eight times the trade size of the largest raceway. Figure 314–20

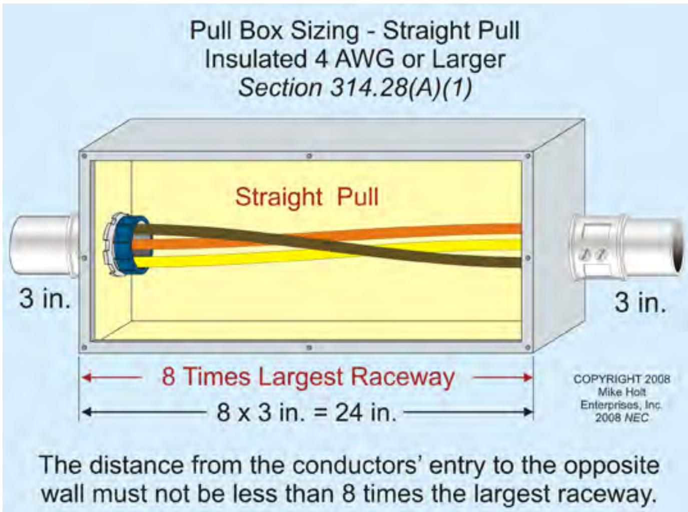

Figure 314–20

(2) Angle Pulls, U Pulls, or Splices.

- Angle Pulls. The distance from the raceway entry to the opposite wall must not be less than six times the trade size of the largest raceway, plus the sum of the trade sizes of the remaining raceways on the same wall and row. Figure 314–21

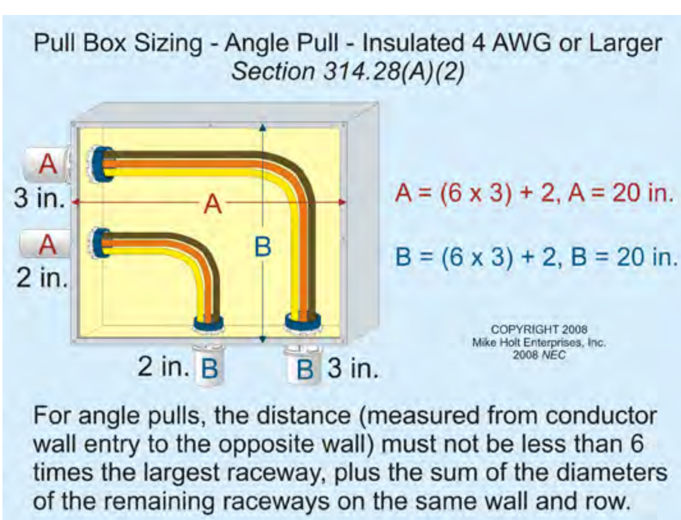

Figure 314–21

- U Pulls. When a conductor enters and leaves from the same wall, the distance from where the raceways enter to the opposite wall must not be less than six times the trade size of the largest raceway, plus the sum of the trade sizes of the remaining raceways on the same wall and row. Figure 314–22

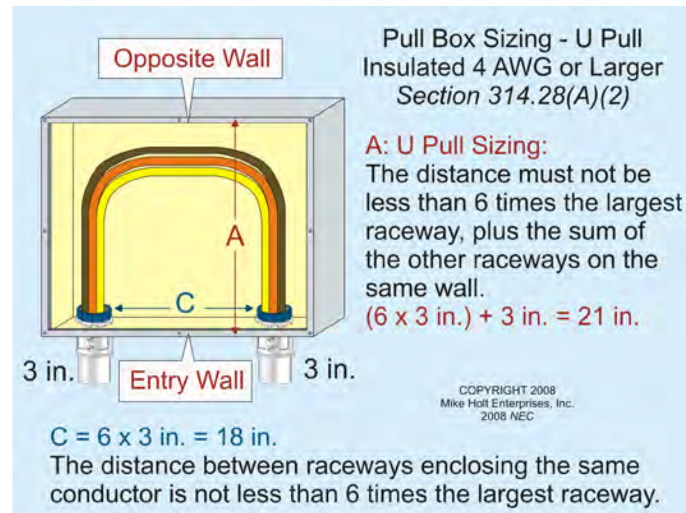

Figure 314–22

- Splices. When conductors are spliced, the distance from where the raceways enter to the opposite wall must not be less than six times the trade size of the largest raceway, plus the sum of the trade sizes of the remaining raceways on the same wall and row. Figure 314–23

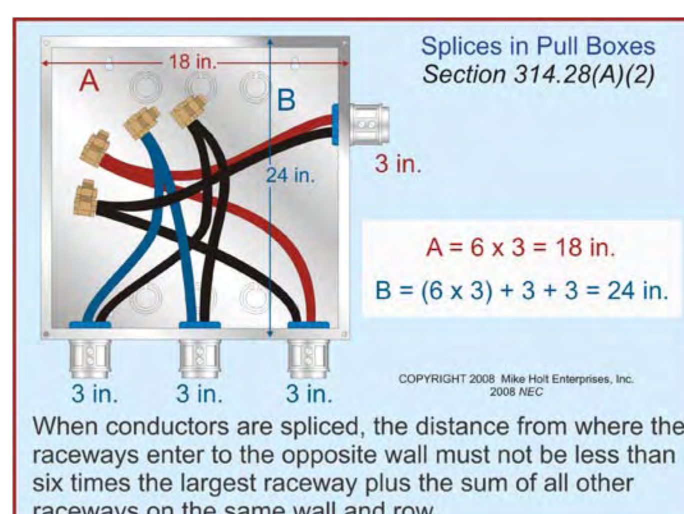

Figure 314–23

- Rows. Where there are multiple rows of raceway entries, each row is calculated individually and the row with the largest distance must be used.
- Distance Between Raceways. The distance between raceways enclosing the same conductor must not be less than six times the trade size of the largest raceway, measured from the raceways' nearest edge-to-nearest edge.

Exception: When conductors enter an enclosure with a removable cover, such as a conduit body or wireway, the distance from where the conductors enter to the removable cover must not be less than the bending distance as listed in Table 312.6(A) for one conductor per terminal. Figure 314–24

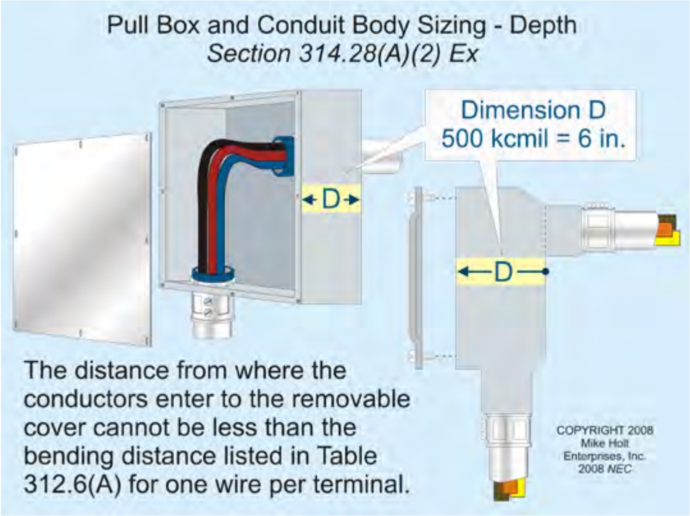

Figure 314–24

(3) Smaller Dimensions. Boxes or conduit bodies smaller than those required in 314.28(A)(1) and 314.28(A)(2) are permitted, if the enclosure is permanently marked with the maximum number and maximum size of conductors.

(C) Covers. Pull boxes, junction boxes, and conduit bodies must have a cover suitable for the conditions. Nonmetallic covers are permitted on any box, but metal covers are only permitted where they can be connected to an equipment grounding conductor of a type recognized in 250.118, in accordance with 250.110 [250.4(A)(3)]. Figure 314–25

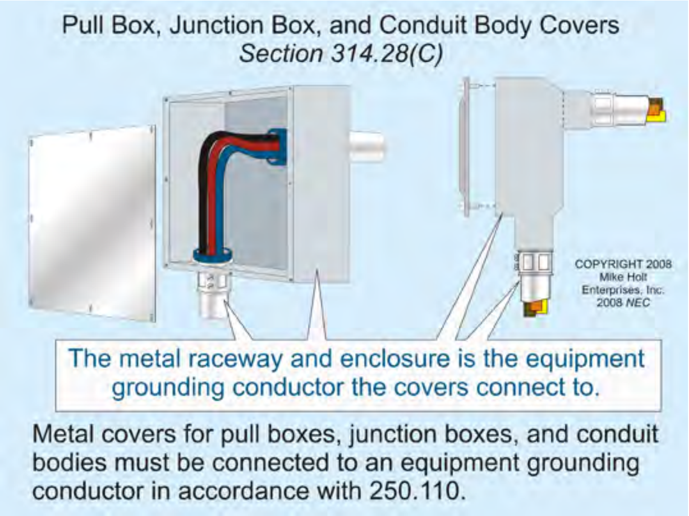

Figure 314–25

78 **314.29 Wiring to be Accessible.** Boxes, conduit bodies, and handhole enclosures must be installed so that the wiring is accessible without removing any part of the building, sidewalks, paving, or earth. Figure 314–26

Exception: Listed boxes and handhole enclosures can be buried if covered by gravel, light aggregate, or noncohesive granulated soil, and their location is effectively identified and accessible for excavation.

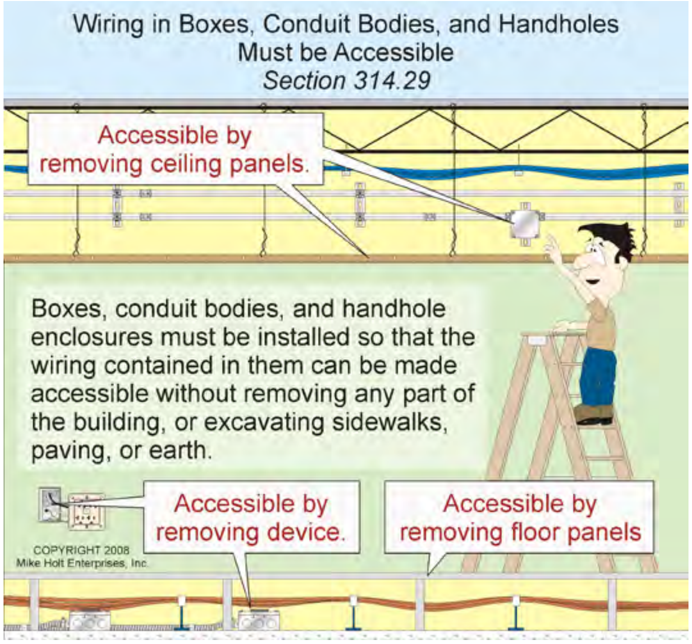

Figure 314–26

ARTICLE

320 Armored Cable (Type AC)

INTRODUCTION TO ARTICLE 320—ARMORED CABLE (TYPE AC)

Armored cable is an assembly of insulated conductors, 14 AWG through 1 AWG, individually wrapped within waxed paper and contained within a flexible spiral metal sheath. The outside appearance of armored cable looks like flexible metal conduit as well as metal-clad cable to the casual observer.

79

320.10 Uses Permitted. Type AC cable is permitted only where not subject to physical damage in the following locations, and in other locations and conditions not prohibited by 320.12 or elsewhere in the *Code*:

(1) For feeders and branch circuits in both exposed and concealed work.

(2) Cable trays.

(3) Dry locations.

(4) Embedded in plaster or brick, except in damp or wet locations.

(5) Air voids where not exposed to excessive moisture or dampness.

FPN: The "Uses Permitted" is not an all-inclusive list, which indicates that other suitable uses are permitted if approved by the authority having jurisdiction.

Author's Comment: Type AC cable is also permitted to be installed above a suspended ceiling used for environmental air [300.22(C)(1)].

80

320.12 Uses Not Permitted. Type AC cable must not be installed in any of the following locations:

(1) Where subject to physical damage.

(2) In damp or wet locations.

(3) In air voids of masonry block or tile walls where such walls are exposed or subject to excessive moisture or dampness.

ARTICLE

330 Metal-Clad Cable (Type MC)

INTRODUCTION TO ARTICLE 330—METAL-CLAD CABLE (TYPE MC)

Metal-clad cable encloses insulated conductors in a metal sheath of either corrugated or smooth copper or aluminum tubing, or spiral interlocked steel or aluminum. The physical characteristics of Type MC cable make it a versatile wiring method that you can use in almost any location, and for almost any application. The most common Type MC cable is the interlocking type, which looks similar to armored cable or flexible metal conduit.

81 330.10 Uses Permitted.

(A) General Uses. Type MC cable is permitted only where not subject to physical damage, and in other locations and conditions not prohibited by 330.12, or elsewhere in the *Code*:

(1) In branch circuits, feeders and services.

(2) In power, lighting, control, and signal circuits.

(3) Indoors or outdoors.

(4) Exposed or concealed.

(5) Directly buried (if identified for the purpose).

(6) In a cable tray.

(7) In a raceway.

(8) As aerial cable on a messenger.

(9) In hazardous (classified) locations as permitted in 501.10(B), 502.10(B), and 503.10.

(10) Embedded in plaster or brick.

(11) In wet locations, if any the following are met:

a. The metallic covering is impervious to moisture.

b. A lead sheath or moisture-impervious jacket is provided under the metal covering.

c. The insulated conductors under the metallic covering are listed for use in wet locations and a corrosion-resistant jacket is provided over the metallic sheath.

(12) Where single-conductor cables are used, all ungrounded conductors and, where used, the neutral conductor must be grouped together to minimize induced voltage on the sheath [300.3(B)].

(B) Specific Uses. Type MC cable can be installed in compliance with Parts II and III of Article 725 and 770.133 as applicable, and in accordance with (1) through (4).

(1) Cable Tray. Type MC cable installed in a cable tray must comply with 392.3, 392.4, 392.6, and 392.8 through 392.80.

(2) Direct Buried. Direct-buried cables must be protected in accordance with 300.5.

(3) Installed as Service-Entrance Cable. Type MC cable is permitted for service entrances, when installed in accordance with 230.43.

(4) Installed Outside of Buildings or Structures. Type MC cable installed outside of buildings or structures must comply with 225.10, 396.10, and 396.12.

FPN: The “Uses Permitted” is not an all-inclusive list, which indicates that other suitable uses are permitted if approved by the authority having jurisdiction.

Author’s Comment: Type MC cable is also permitted to be installed above a suspended ceiling used for environmental air [300.22(C)(1)].

330.12 Uses Not Permitted. Type MC cable must not be used where:

(1) Subject to physical damage.

(2) Exposed to the destructive corrosive conditions in (a) or (b), unless the metallic sheath or armor is resistant or protected by material resistant to the conditions:

(a) Direct burial in the earth or embedded in concrete unless identified for the application.

(b) Exposed to cinder fills, strong chlorides, caustic alkalis, or vapors of chlorine or of hydrochloric acids.

ARTICLE

334 Nonmetallic-Sheathed Cable (Types NM and NMC)

INTRODUCTION TO ARTICLE 334—NONMETALLIC-SHEATHED CABLE (TYPES NM AND NMC)

Nonmetallic-sheathed cable is flexible, inexpensive, and easily installed. It provides very limited physical protection of the conductors, so the installation restrictions are strict. Its low cost and relative ease of installation make it a common wiring method for residential and commercial branch circuits.

83 334.10 Uses Permitted.

Type NM and Type NMC cables can be used in the following:

(1) One- and two-family dwellings. Figure 334–1

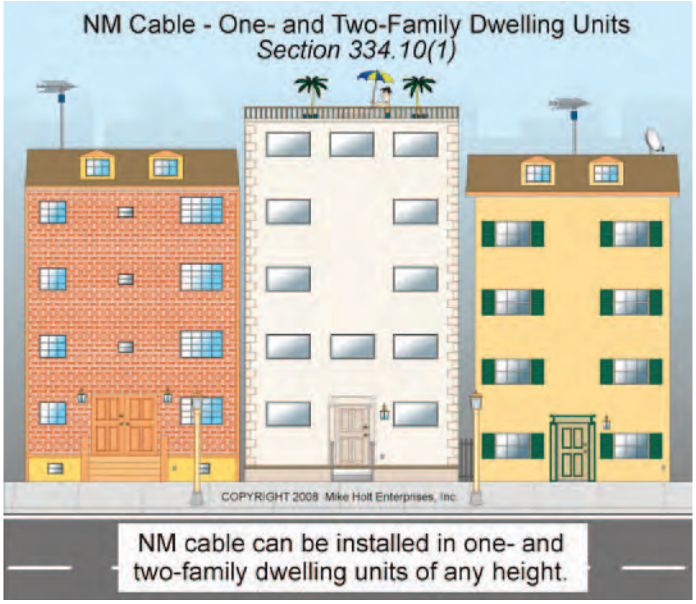

Figure 334–1

(2) Multifamily dwellings permitted to be of Types III, IV, and V construction. Figure 334–2

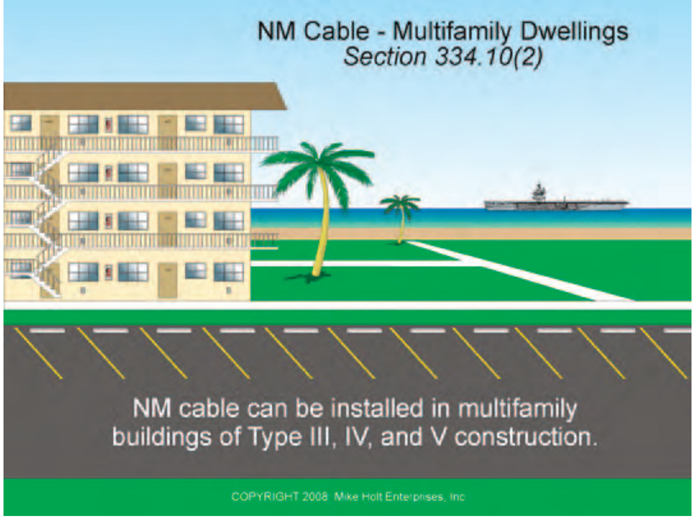

Figure 334–2

(3) Other structures permitted to be of Types III, IV, and V construction, except as prohibited in 334.12. Cables must be concealed within walls, floors, or ceilings that provide a thermal barrier of material with at least a 15-minute finish rating, as identified in listings of fire-rated assemblies. Figure 334–3

Author's Comment: See the definition of "Concealed" in Article 100.

FPN No. 1: Building constructions are defined in NFPA 220, Standard on Types of Building Construction, the applicable building code, or both.

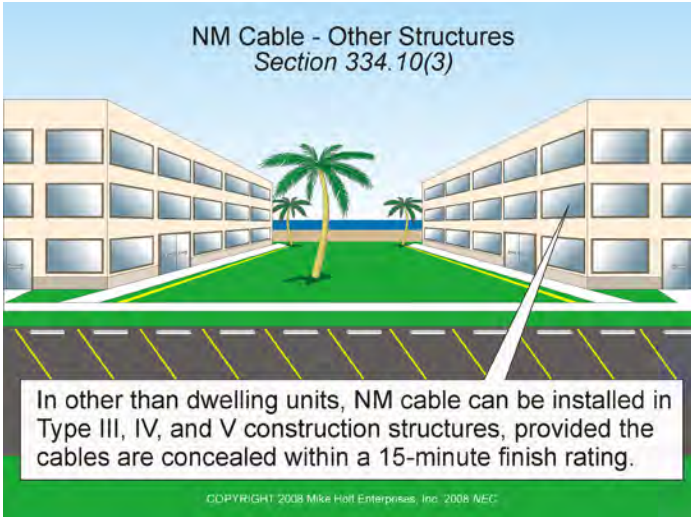

Figure 334–3

FPN No. 2: See Annex E for the determination of building types [NFPA 220, Table 3-1].

(4) Cable trays, where the cables are identified for this use.

FPN: See 310.10 for temperature limitation of conductors.

84 334.12 Uses Not Permitted.

(A) Types NM, NMC, and NMS.

(1) In any dwelling or structure not specifically permitted in 334.10(1), (2), and (3).

Exception: NM, NMC, and NMS cable is permitted in Type I and II construction when installed within a raceway.

(2) Exposed in dropped or suspended ceilings in other than one- and two-family and multifamily dwellings. Figure 334–4

(3) As service-entrance cable.

(4) In commercial garages having hazardous (classified) locations, as defined in 511.3.

(5) In theaters and similar locations, except where permitted in 518.4(B).

(6) In motion picture studios.

(7) In storage battery rooms.

(8) In hoistways, or on elevators or escalators.

(9) Embedded in poured cement, concrete, or aggregate.

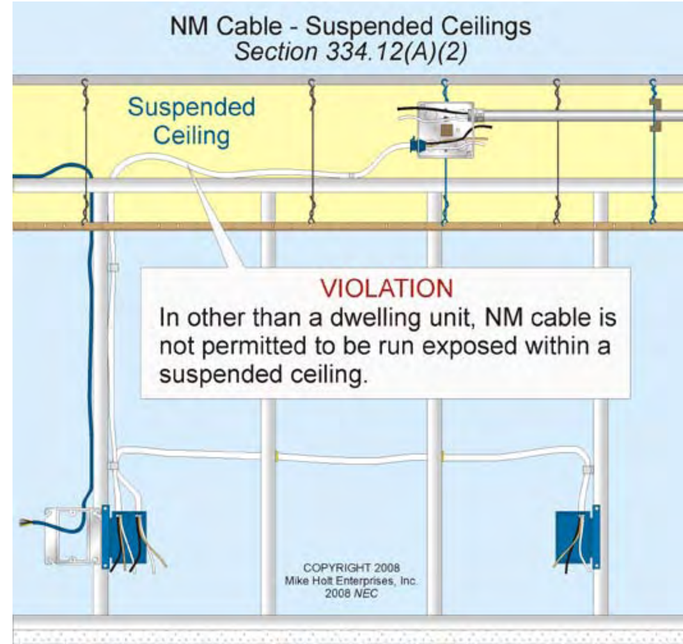

Figure 334–4

(10) In any hazardous (classified) location, except where permitted by the following:

a. 501.10(B)(3)
b. 502.10(B)(3)
c. 504.20

(B) Type NM. Type NM cables must not be used under the following conditions, or in the following locations:

(1) Where exposed to corrosive fumes or vapors.

(2) Where embedded in masonry, concrete, adobe, fill, or plaster.

(3) In a shallow chase in masonry, concrete, or adobe and covered with plaster, adobe, or similar finish.

(4) In wet or damp locations.

Author's Comment: Type NM cable isn't permitted in ducts, plenums, or other environmental air spaces [300.22], or for wiring in patient care areas [517.13].

ARTICLE 338 Service-Entrance Cable (Types SE and USE)

INTRODUCTION TO ARTICLE 338—SERVICE-ENTRANCE CABLE (TYPES SE AND USE)

Service-entrance cable is a single conductor or multiconductor assembly with or without an overall moisture-resistant covering. This cable is used primarily for services not over 600V, but can also be used for feeders and branch circuits as limited by this article.

85 338.10 Uses Permitted.

(A) Service-Entrance Conductors. Service-entrance cable used as service-entrance conductors must be installed in accordance with Article 230.

(B) Branch Circuits or Feeders.

(2) Uninsulated Conductor. SE cable is permitted for use where the insulated conductors are used for circuit wiring, and the uninsulated conductor is only used for equipment grounding. Figure 338–1

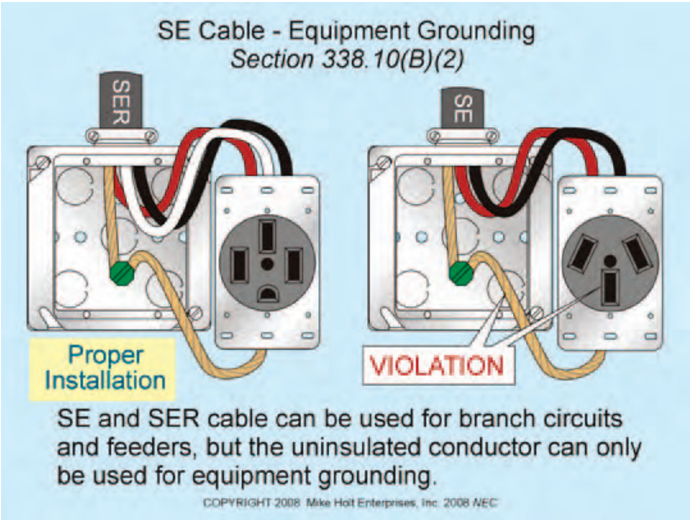

Figure 338–1

(3) Temperature Limitations. SE cable must not be subjected to conductor temperatures exceeding its insulation rating.

(4) Installation Methods for Branch Circuits and Feeders. SE cable used for branch circuits or feeders must comply with (a) and (b).

(a) Interior Installations. SE cable used for interior branch circuit or feeder wiring must be installed in accordance with the same requirements as Type NM Cable—Article 334. Figure 338–2

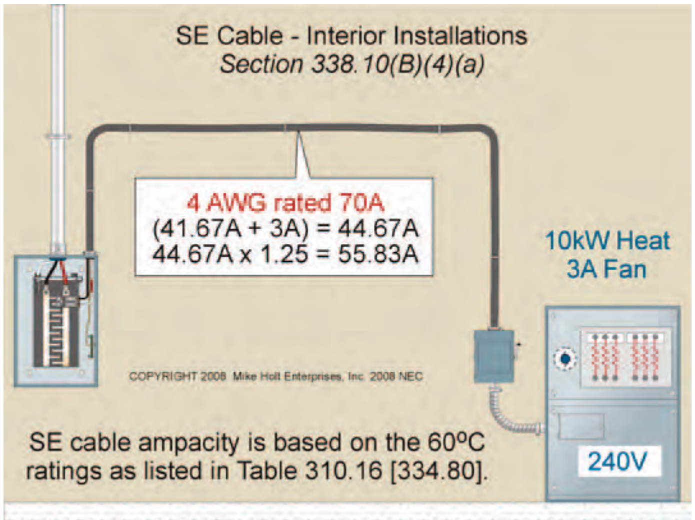

Figure 338–2

> **Author's Comment:** Where Type SE cable is used for interior wiring, its ampacity is limited to the 60°C insulation rating listed in Table 310.16 [334.80].

> **CAUTION:** *Underground service-entrance cable (USE) must not be used for interior wiring because it doesn't have flame-retardant insulation.*

(b) Exterior Installations. Service-entrance cable used for exterior branch circuits or feeders must be installed in accordance with Part I of Article 225.

ARTICLE 362

Electrical Nonmetallic Tubing (Type ENT)

INTRODUCTION TO ARTICLE 362—ELECTRICAL NONMETALLIC TUBING (TYPE ENT)

Electrical nonmetallic tubing is a pliable, corrugated, circular raceway made of polyvinyl chloride. In some parts of the country, the field name for electrical nonmetallic tubing is “Smurf Pipe” or “Smurf Tube,” because it was only available in blue when it originally came out at the time the children’s cartoon characters “The Smurfs” were most popular. Today, the raceway is available in a rainbow of colors such as white, yellow, red, green, and orange, and is sold in both fixed lengths and on reels.

86 362.12 Uses Not Permitted.

(1) In any hazardous (classified) location, except as permitted by 504.20 and 505.15(A)(1).

(2) For the support of luminaires or equipment. See 314.2.

(3) Where the ambient temperature exceeds 50°C (122°F).

(4) Where conductors operate at a temperature above the temperature rating of the raceway. Figure 362–1

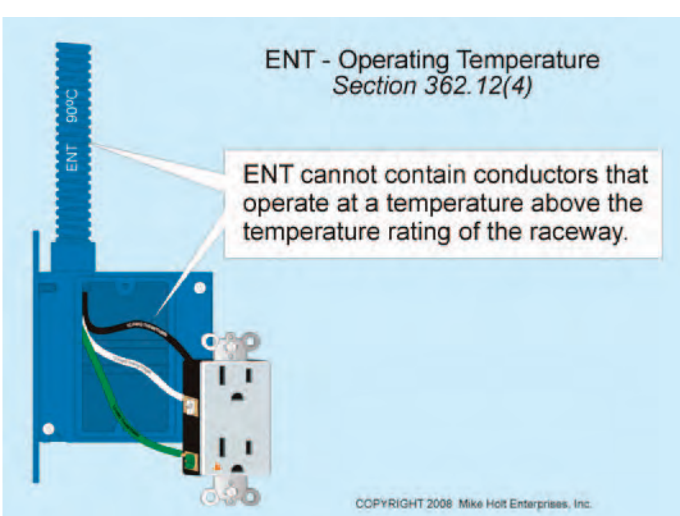

Figure 362–1

Exception: Conductors rated at a temperature above the electrical nonmetallic tubing temperature rating are permitted, provided the conductors don’t operate at a temperature above the electrical nonmetallic tubing’s listed temperature rating.

(5) For direct earth burial.

> **Author’s Comment:** Electrical nonmetallic tubing can be encased in concrete [362.10(6)].

(6) As a wiring method for systems over 600V.

(7) Exposed in buildings over three floors, except as permitted by 362.10(2) and (5) Ex.

(8) In assembly occupancies or theaters, except as permitted by 518.4 and 520.5.

(9) Exposed to the direct rays of the sun for an extended period, unless listed as sunlight resistant.

> **Author’s Comment:** Exposing electrical nonmetallic tubing exposed to the direct rays of the sun for an extended time may result in the product becoming brittle, unless it is listed to resist the effects of ultraviolet (UV) radiation. Figure 362–2

(10) Where subject to physical damage.

> **Author’s Comment:** Electrical nonmetallic tubing is prohibited in ducts, plenums, other environmental air-handling spaces [300.22], and patient care area circuits in health care facilities [517.13(A)].

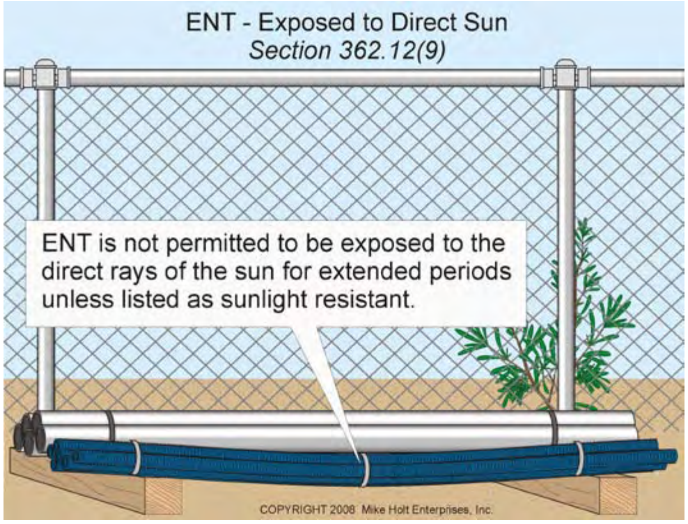
ENT - Exposed to Direct Sun
Section 362.12(9)
ENT is not permitted to be exposed to the direct rays of the sun for extended periods unless listed as sunlight resistant.
COPYRIGHT 2008 Mike Holt Enterprises, Inc.

Figure 362–2

ARTICLE

376 Metal Wireways

INTRODUCTION TO ARTICLE 376—METAL WIREWAYS

Metal wireways are commonly used where access to the conductors within the raceway is required to make terminations, splices, or taps to several devices at a single location. High cost precludes their use for other than short distances, except in some commercial or industrial occupancies where the wiring is frequently revised.

Author's Comment: Both metal wireways and nonmetallic wireways are often called "troughs" or "gutters" in the field.

87 376.12 Uses Not Permitted.

(1) Subject to severe physical damage.

(2) Subject to corrosive environments.