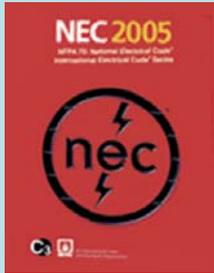


Wiring Methods Part One

2005 NEC, NFPA 70



Chapter 3. Wiring Methods and Materials

Article 300 Wiring Methods

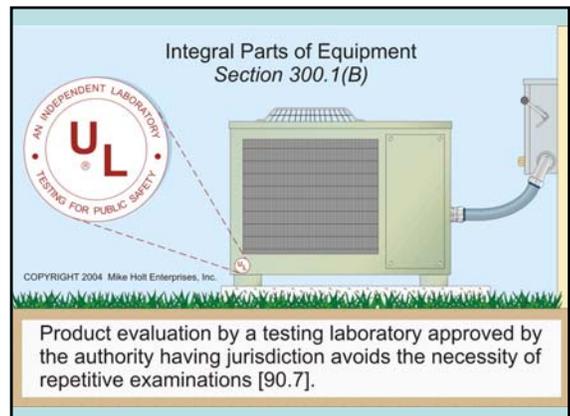
- Article 300 contains the general requirements for all wiring methods included in the NEC.
- This article is primarily concerned with how you install, route, splice, protect, and secure conductors and raceways.

300.1 Scope

- (A) Wiring Installations. Article 300 contains the general requirements for power and lighting wiring methods.
- The requirements contained in Article 300 do not apply to the wiring methods for signaling and communications systems.

300.1 Scope

- (B) Integral Parts of Equipment. The requirements contained in Article 300 do not apply to the internal parts of electrical equipment.



300.1 Scope

- (C) Metric Designators and Trade Sizes. Metric designators for raceway trade sizes are given in Table 300.1(C).
 - Trade Size Metric
 - 3/8" 12
 - 1/2" 16
 - 3/4" 21
 - 1" 27

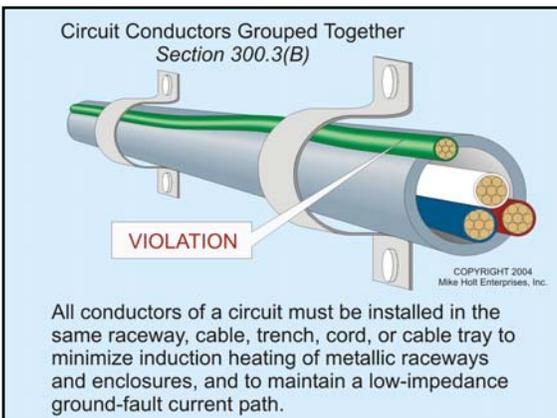
300.3 Conductors

- (A) Conductors. Conductors must be installed within a raceway, cable, or enclosure.



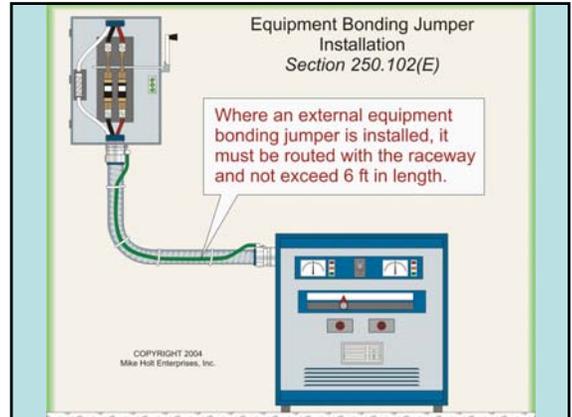
300.3 Conductors

- (B) Circuit Conductors Grouped Together. All conductors of a circuit must be installed in the same raceway, cable, trench, cord, or cable tray, except ...



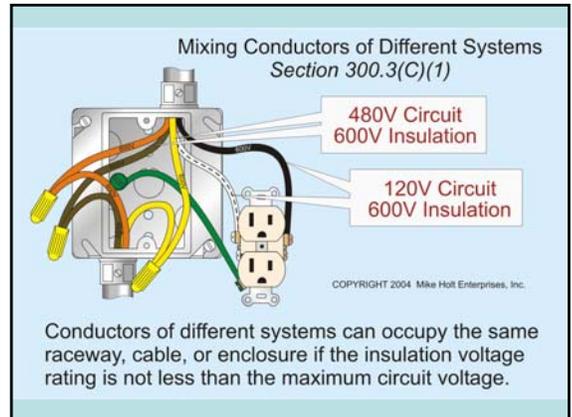
300.3 Conductors

- (B) Circuit Conductors Grouped Together.
- (2) Grounding and Bonding Conductors. Equipment bonding conductors can be installed outside a raceway if the bonding jumper is installed in accordance with 250.102(E).



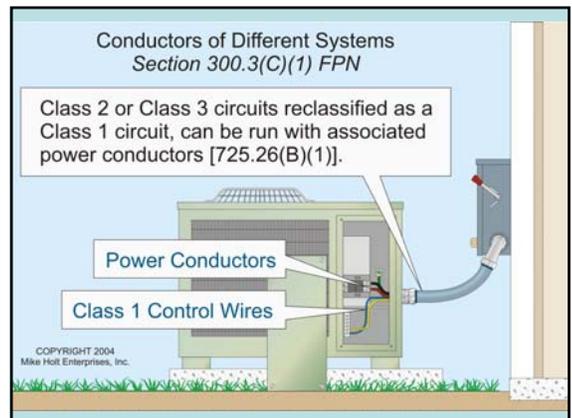
300.3 Conductors

- (C) Conductors of Different Systems.
- (1) Mixing. Power conductors of different systems can occupy the same raceway, cable, or enclosure if all conductors have an insulation voltage rating not less than the maximum circuit voltage.



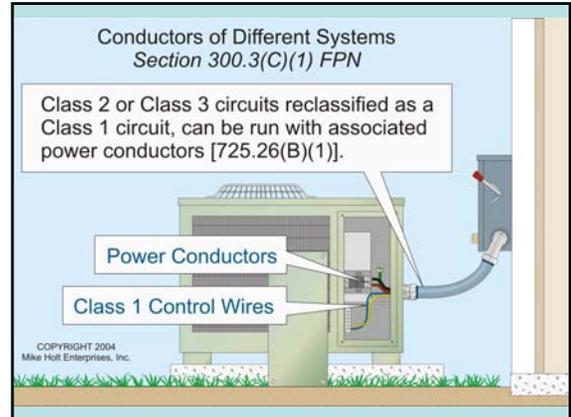
300.3 Conductors

- (C) Conductors of Different Systems.
- (1) Mixing. Control, signal, and communications wiring must be separated from power and lighting circuits so the higher-voltage conductors do not accidentally energize them.



300.3 Conductors

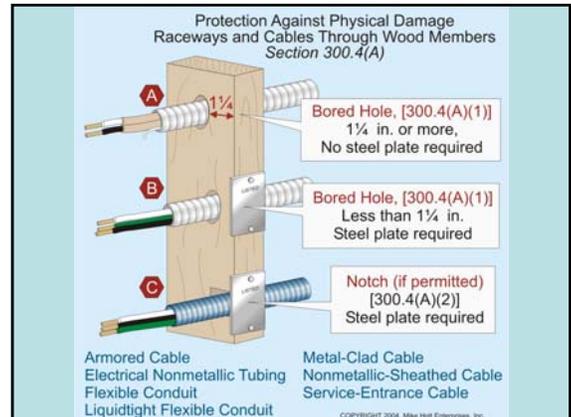
- (C) Conductors of Different Systems.
- (1) Mixing. Exceptions allow Class 1 or Class 2 reclassified [725.52 Ex. 2] as Class 1 control circuits to be run with associated power conductors.



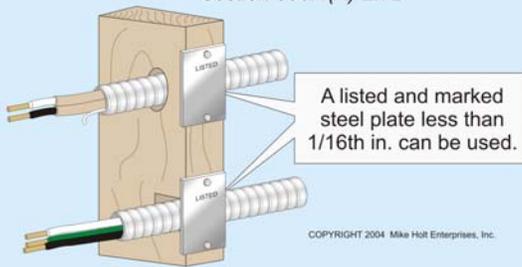
300.4

Protection Against Physical Damage

- (A) Cables and Raceways Through Wood Members.
- Armored Cable, Article 320
- ENT, Article 362
- Flexible Metal Conduit, Article 348
- Liquidtight Flexible Metal Conduit, Article 350
- Metal-Clad Cable, Article 330
- NM Cable, Article 334
- Service-Entrance Cable, Article 338



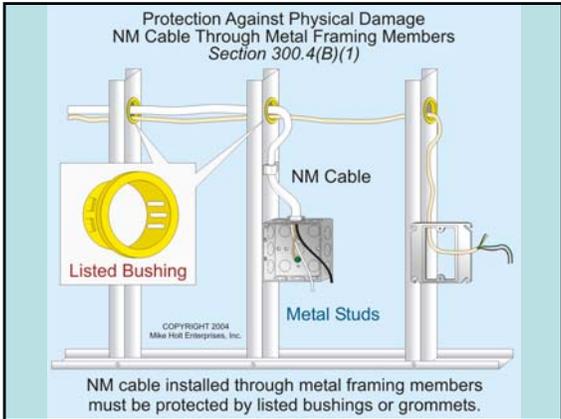
Protection Against Physical Damage Raceways and Cables Through Wood Members Section 300.4(A) Ex 2



300.4

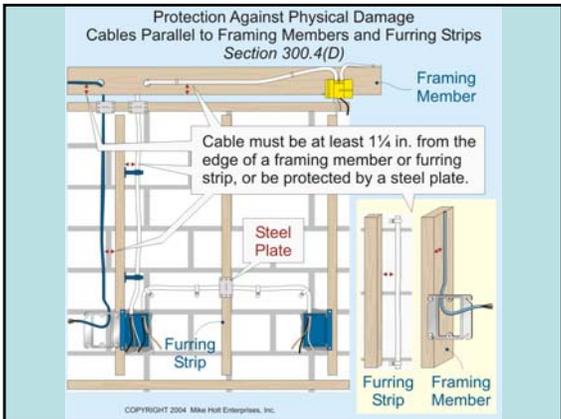
Protection Against Physical Damage

- (B) Through Metal Framing Members.
- (1) NM Cable. Where NM cables pass through factory or field openings in metal framing members, the cable must be protected by listed bushings or listed grommets that cover all metal edges.
- The protection fitting must be securely fastened in the opening before the installation of the cable.



300.4
 Protection Against Physical Damage

- (D) Cables and Raceways Parallel to Framing Members and Furring Strips. Cables or raceways run parallel to framing members or furring strips must be protected where they are likely to be penetrated by nails or screws, by installing the wiring method so it isn't less than 1¼ in. from the nearest edge of the framing member or furring strips... Ex. 1: Protection isn't required for RMC, IMC, RNC, or EMT.



300.4
 Protection Against Physical Damage

- (F) Insulating Bushings. Where raceways contain conductors 4 AWG and larger that enter an enclosure, the conductors must be protected from abrasion during and after installation by a fitting that provides a smooth, rounded insulating surface, such as an insulating bushing.

Protection Against Physical Damage
 Raceway Terminations
 Section 300.4(F)

Termination Type	Wire Size	Code
Threaded IMC	ANY	IMC - 342.46
Threaded Rigid	ANY	RMC - 344.46
IMC - Rigid	4 AWG and LARGER	
IMC - Rigid	6 AWG and SMALLER	
EMT	4 AWG and LARGER	EMT
EMT	6 AWG and SMALLER	
RNC - ENT	4 AWG and LARGER	RNC - 352.46
RNC - ENT	6 AWG and SMALLER	ENT - 362.46

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CT Supplement

- 300.4.1 Drilling and Notching
 - Joists rafters and beams
 - No notches in the middle third
 - Notches limited to one-third length
 - Notches limited to one-sixth depth
 - Notches on ends limited to one-fourth
 - Holes shall not be closer than 2 inches to edge
 - Hole diameters limited to one-third
 - Multiple holes shall be separated by 2 inches
 - Holes and notches shall be separated by 2"
 - Notches in cantilevered portions are permitted provided:
 - The cantilever limited to 24 inches in length
 - Remaining portion minimum of 4 inches

CT Supplement

- 300.4.1. Drilling and Notching
 - Engineered Wood Products
 - Cuts, notches and holes bored in trusses, laminated veneer lumber, glue-laminated members or I-joists are not permitted unless the effects of such penetrations are specifically considered in the design of the member and permitted by the manufacturer

CT Supplement

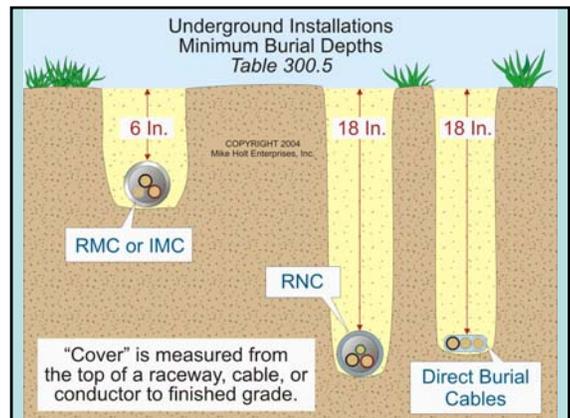
- 300.4.1. Drilling and Notching
 - Studs
 - Notches not to exceed 25%
 - Notches in non-bearing stud walls – 40 %
 - Holes limited to 40%
 - Holes can be no closer than 5/8 inch
 - Holes to 60% allowed in bearing or exterior walls if:
 - Such studs are doubled
 - Limited to 2 successive studs
 - Approved stud shoes may be used

CT Supplement

- 300.4.1 Drilling and Notching
 - Top Plates:
 - Interior bearing walls or exterior walls
 - Top plates notched or cut or drilled over 50%:
 - » Galvanized metal tie 16 gage and 1-1/2 inch wide with 8-16 d nail on each side, or
 - » Entire side of the wall on the notch side is covered by wood structural panel sheathing

300.5 Underground Installations

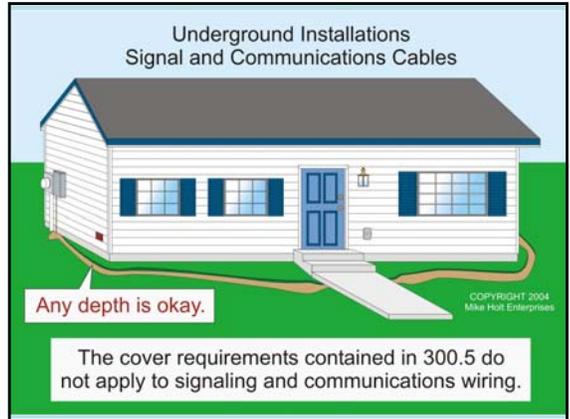
- (A) Minimum Burial Depths. When cables and raceways are run underground, they must have a minimum "cover" in accordance with Table 300.5.



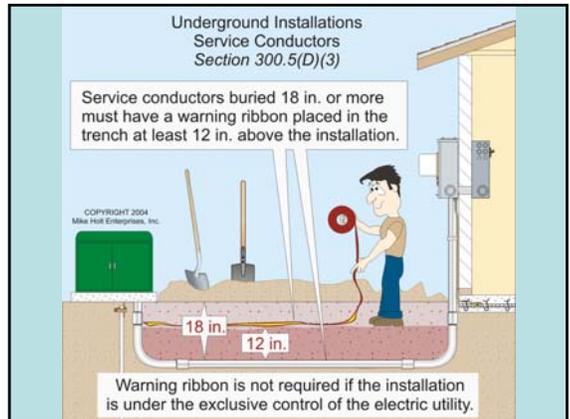
**Underground Installations
Minimum Burial Depths
Table 300.5**

	UF or USE Cables or Conductors	RMC or IMC	RNC (PVC) not encased in concrete	Residential 15 & 20A GFCI Branch Circuits
Applications NOT listed below	24	6	18	12
STREET Driveway Parking Lot	24	24	24	24
DRIVEWAYS One - Two Family	18	18	18	12
SOLID ROCK With not less than 2 in. of concrete	Raceway Only			Raceway Only

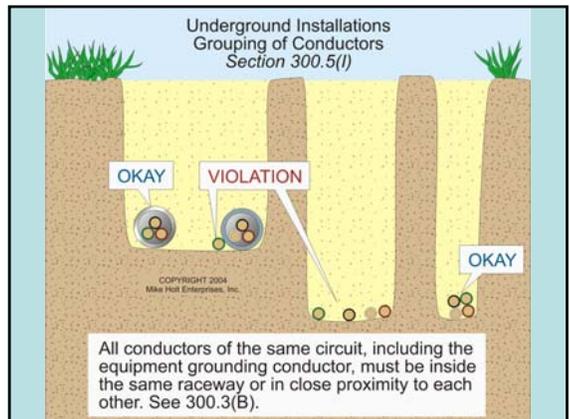
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- ### 300.5 Underground Installations
- (D) Protecting Underground Cables and Conductors from Damage.
 - (3) Service Conductors. Service conductors not under the exclusive control of the electric utility buried 18 in. or more below grade, must have their location identified by a warning ribbon placed in the trench not less than 1 ft above the underground installation.

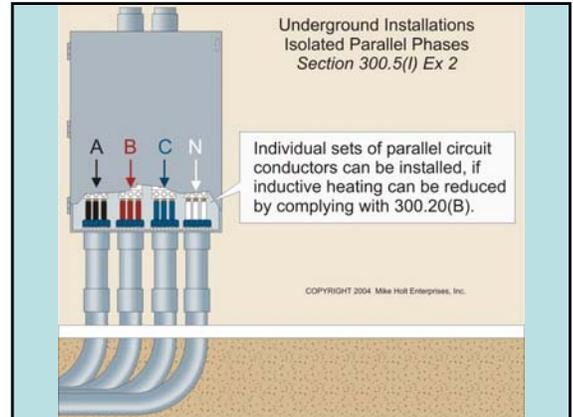


- ### 300.5 Underground Installations
- (I) Conductors Grouped Together. All conductors of the same circuit, including the equipment grounding (bonding) conductor, must be inside the same raceway or in close proximity to each other.



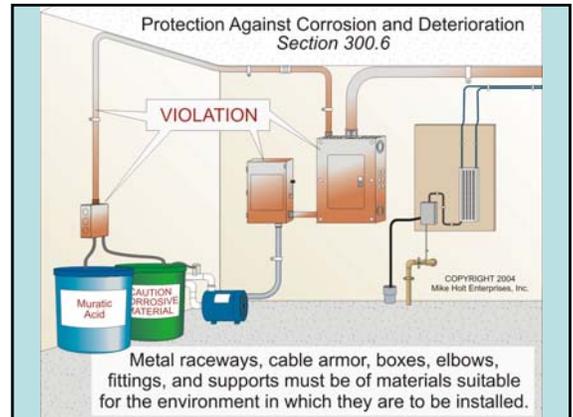
300.5 Underground Installations

- (I) Conductors Grouped Together.
- Ex. 2: Individual sets of parallel circuit conductors can be installed in underground nonmetallic raceways, if inductive heating at raceway terminations is reduced by complying with 300.20(B).



300.6 Protection Against Corrosion and Deterioration

- Raceways, cable trays, cablebus, auxiliary gutters, cable armor, boxes, cable sheathing, cabinets, elbows, couplings, fittings, supports, and support hardware must be suitable for the environment.

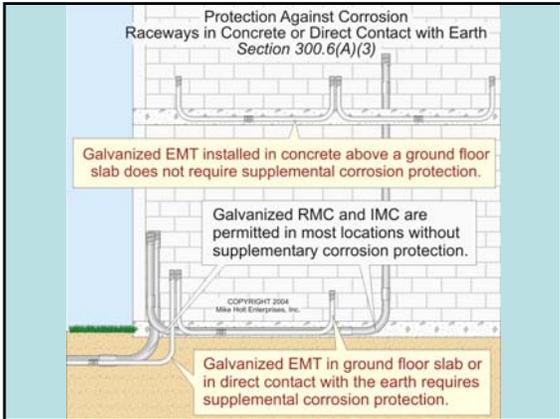


300.6 Protection Against Corrosion and Deterioration

- (A) Ferrous Metal Equipment. Where corrosion protection is necessary, such as in underground and in wet locations, and the conduit is threaded in the field, the threads must be coated with an electrically conductive, corrosion-resistant compound approved by the AHJ, such as cold zinc.

300.6 Protection Against Corrosion and Deterioration

- (A) Ferrous Metal Equipment.
- (3) In Concrete or in Direct Contact with the Earth. Ferrous metal raceways, fittings, supports and support hardware can be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences where made of material approved by the AHJ for the condition, or where provided with corrosion protection approved by the AHJ for the condition.

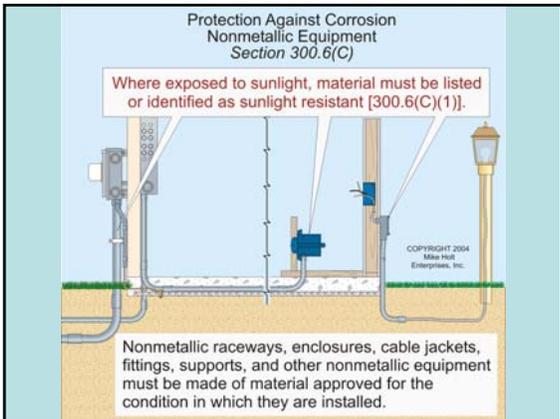


300.6 Protection Against Corrosion and Deterioration

- (C) Nonmetallic Equipment. Nonmetallic raceways, cable trays, boxes, cables with a nonmetallic outer jacket, enclosures, raceway, fittings, supports, and support hardware must be approved by the AHJ for the condition.

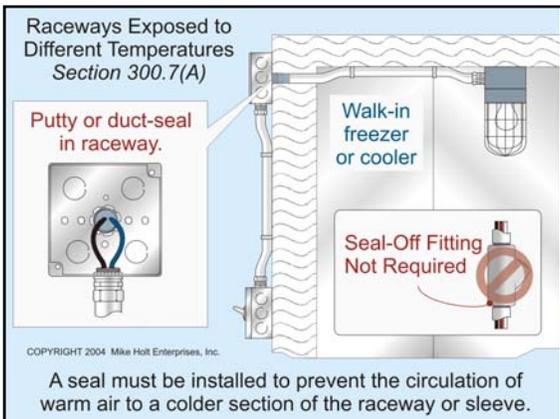
300.6 Protection Against Corrosion and Deterioration

- (C) Nonmetallic Equipment.
- (1) Exposed to Sunlight. Where exposed to sunlight, the materials must be listed or identified as sunlight resistant.
- (2) Chemical Exposure. Where subject to exposure to chemical solvents, vapors, splashing or immersion, materials or coatings must either be inherently resistant to chemicals based upon their listing or be identified for the specific chemical reagent.



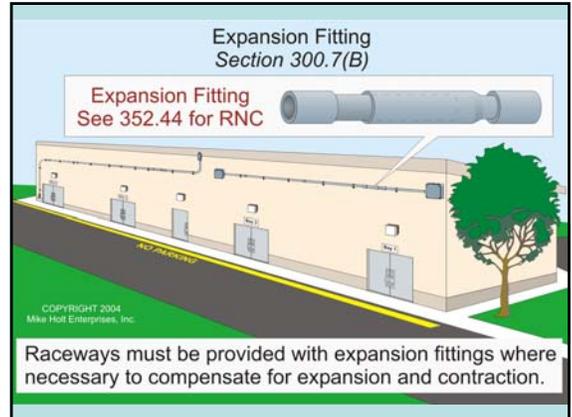
300.7 Raceways Exposed to Different Temperatures

- (A) Sealing. Where a raceway is subjected to different temperatures and condensation is known to be a problem, the raceway must be filled with a material approved by the AHJ that will prevent the circulation of warm air to a colder section of the raceway.
- An explosionproof seal isn't required for this purpose.



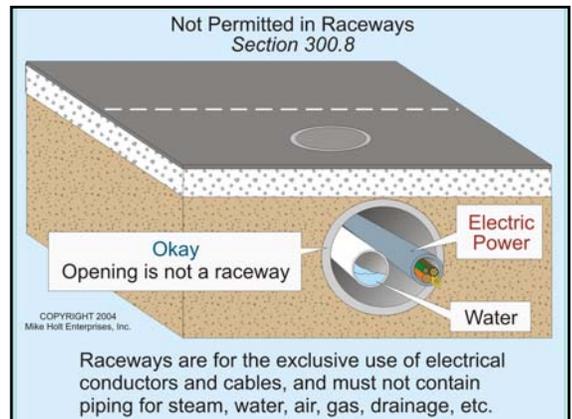
300.7 Raceways Exposed to Different Temperatures

- (B) Expansion Fittings. Raceways must be provided with expansion fittings where necessary to compensate for thermal expansion and contraction.
- FPN: Table 352.44(A) provides the expansion characteristics for RNC. The expansion characteristics for metal raceways are determined by multiplying the values from Table 352.44(A) by 0.20.



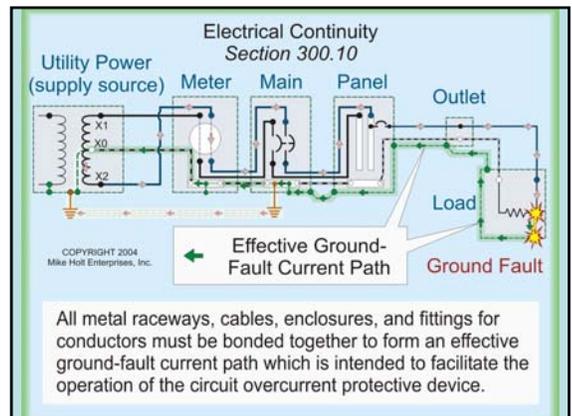
300.8 Not Permitted in Raceways

- Raceways are designed for the exclusive use of electrical conductors and cables, and cannot contain nonelectrical components, such as pipes or tubes for steam, water, air, gas, drainage, etc.



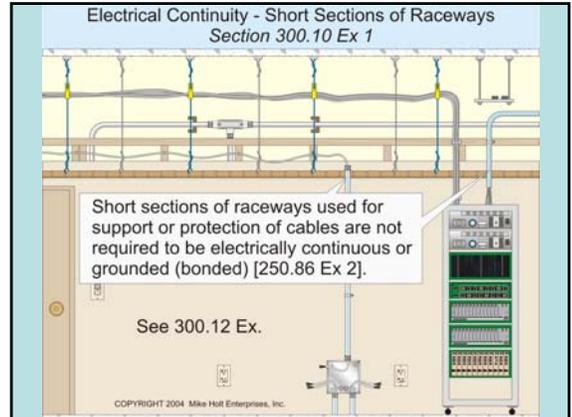
300.10 Electrical Continuity

- All metal raceways, cable, boxes, fittings, cabinets, and enclosures for conductors must be metallically joined together to form a continuous low-impedance fault-current path that is capable of carrying any fault current likely to be imposed on it. Metal raceways and cable assemblies must be mechanically secured to boxes, fittings, cabinets, and other enclosures.



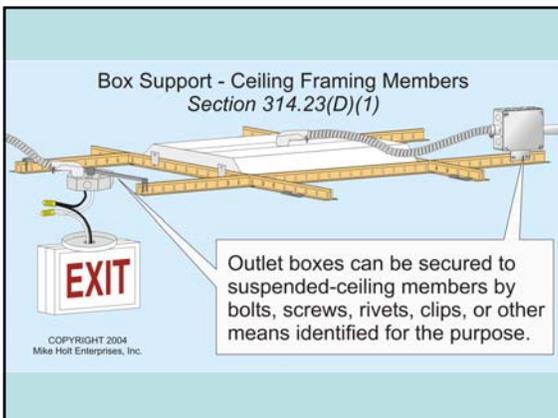
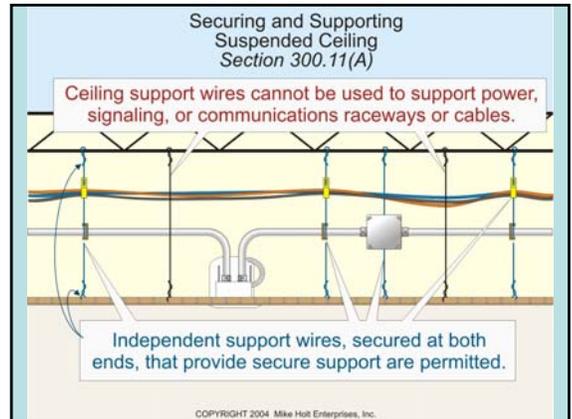
300.10 Electrical Continuity

- Ex. 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 bonded to an effective ground-fault current path [250.86 Ex. 2 and 300.12 Ex].



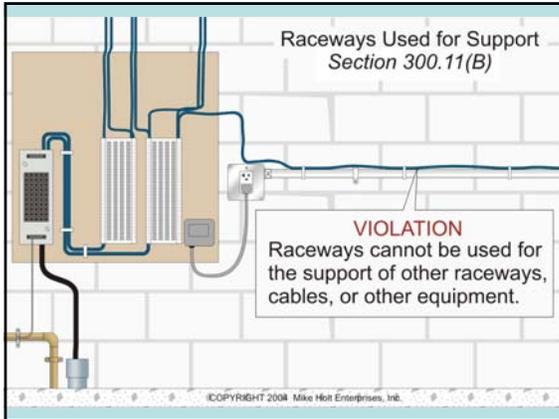
300.11 Securing and Supporting

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



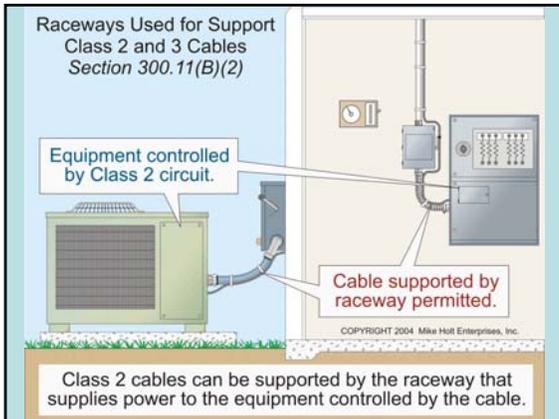
300.11 Securing and Supporting

- (B) Raceways Used for Support. Raceways must not be used as a means of support for other raceways, cables, or nonelectrical equipment, except ...



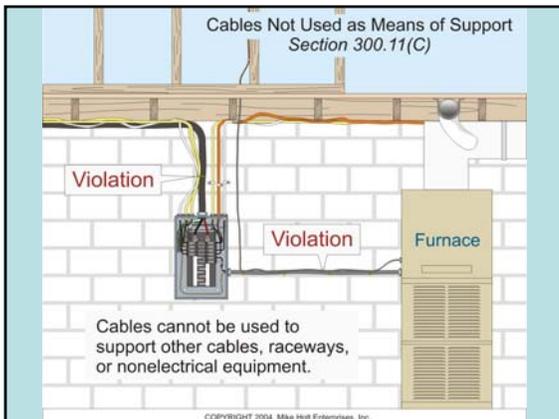
300.11 Securing and Supporting

- (B) Raceways Used for Support.
- (2) Class 2 and 3 Circuits. Class 2 and 3 cables can be supported to the raceway that supplies power to the equipment controlled by the Class 2 or 3 circuit;



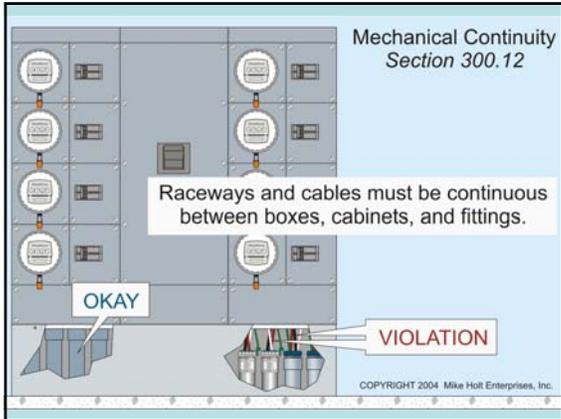
300.11 Securing and Supporting

- (C) Cables Not Used as Means of Support. Cables cannot be used to support other cables, raceways, or nonelectrical equipment.



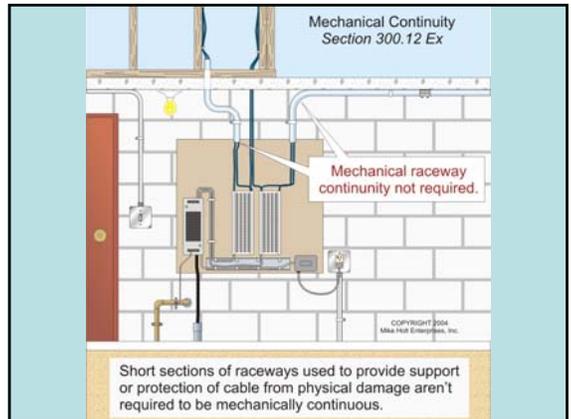
300.12 Mechanical Continuity

- Raceways and cable sheaths must be mechanically continuous between boxes, cabinets, and fittings.



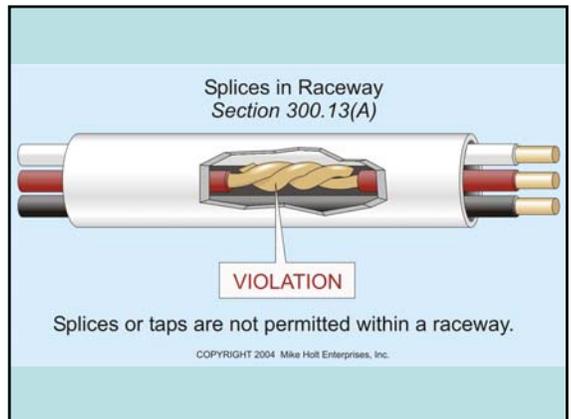
300.12 Mechanical Continuity

- Ex: Short sections of raceways used to provide support or protection of cable from physical damage aren't required to be mechanically continuous.



300.13 Splices and Pigtails

- (A) Conductor Splices. Conductors in raceways must be continuous between all points of the system, which means that splices cannot be made in raceways.



300.13 Splices and Pigtails

- (B) Conductor Continuity (Pigtail). Continuity of the grounded conductor of a multiwire branch circuit must not be interrupted by the removal of a wiring device. Therefore, the grounded conductors must be spliced together, and a pigtail be provided for the wiring device.

Conductor Continuity (Pigtail)
Multiwire Circuit
Section 300.13(B)

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Continuity of the grounded neutral conductor of a multiwire branch circuit must not be interrupted by the removal of a wiring device.

Danger of Open Neutral
on a Multiwire Circuit

Okay

Proper Connection

Parallel Circuit
Voltage drop of television = 120V
Voltage drop of hair dryer = 120V

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Danger of Open Neutral
on a Multiwire Circuit

Danger

Open Neutral

Series Circuit
Voltage drop of television = 160V
Voltage drop of hair dryer = 80V

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Overload on Neutral
Section 300.13(B)

Correct Connection
 $20A - 15A = 5A$

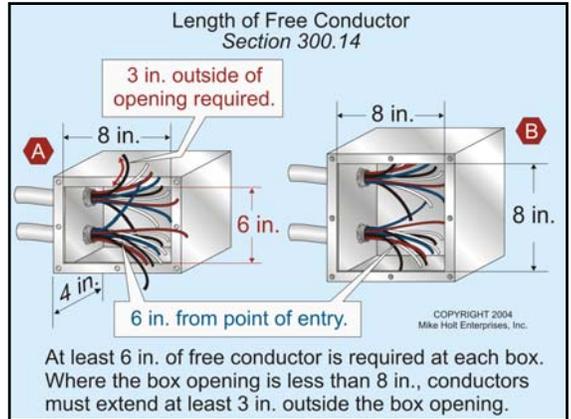
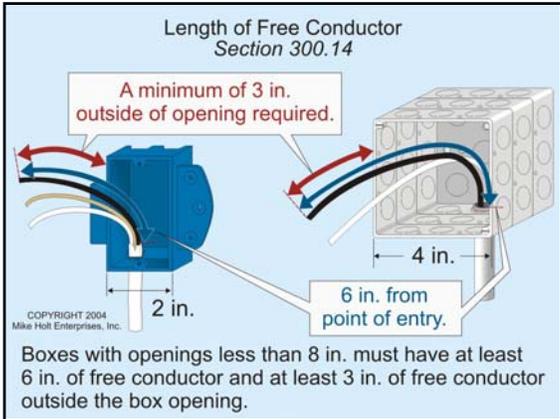
DANGER
 $20A + 15A = 35A$

Failure to terminate the ungrounded (hot) conductors to different phases can cause the grounded neutral conductor to be overloaded, which can cause a fire.

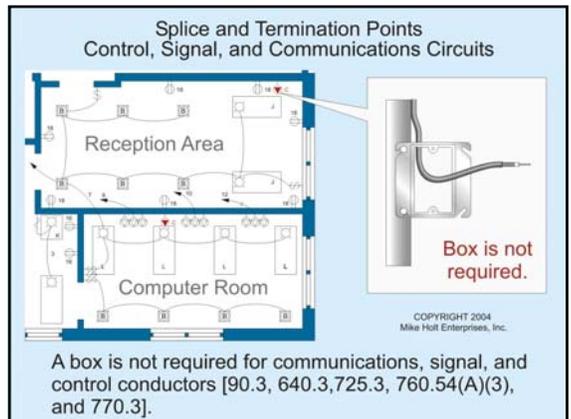
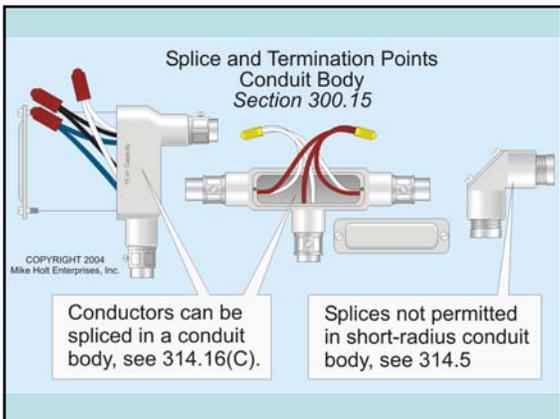
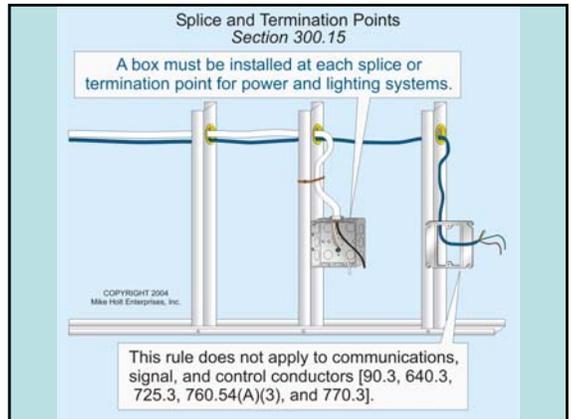
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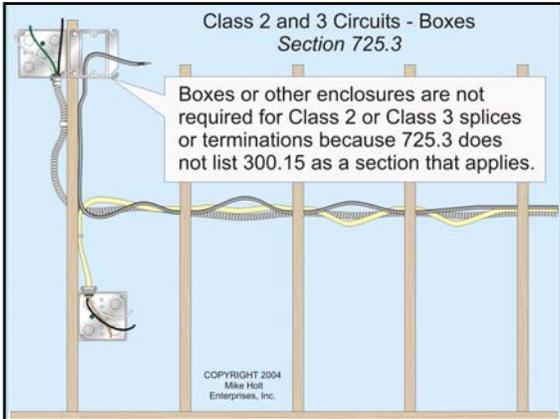
300.14 Length of Free Conductors

- 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.



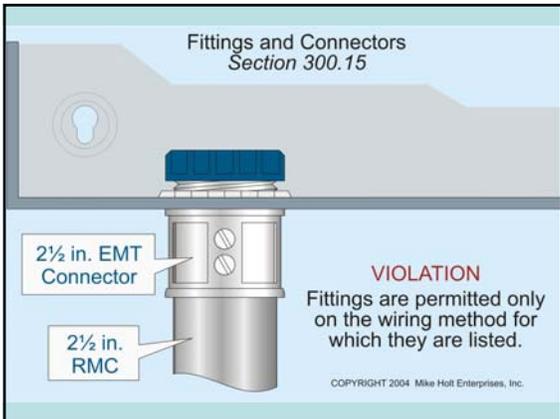
- ### 300.15 Boxes or Conduit Bodies
- A box must be installed at each splice or termination point, except as permitted for: Figs 300-43 through 300-46
 - Cabinet or Cutout Boxes, 312.8
 - Conduit Bodies, 314.16(C), Fig 300-37
 - Luminaires, 410.31
 - Surface Raceways, 386.56 and 388.56
 - Wireways, 376.56





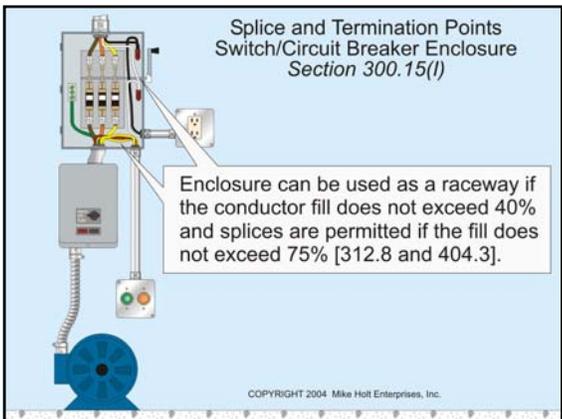
300.15 Boxes or Conduit Bodies

- Fittings and Connectors. Fittings can only be used with the specific wiring methods for which they are listed and designed.



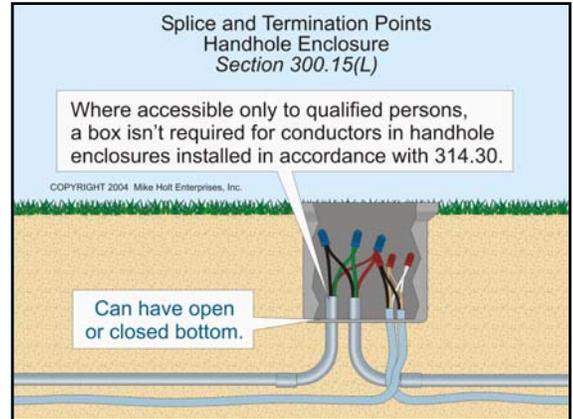
300.15 Boxes or Conduit Bodies

- (l) 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 protection devices if the splices or taps do not 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.



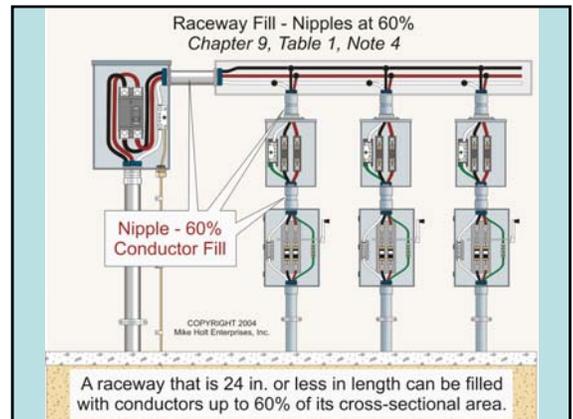
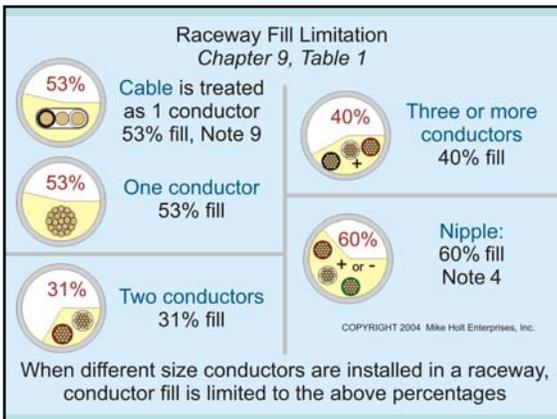
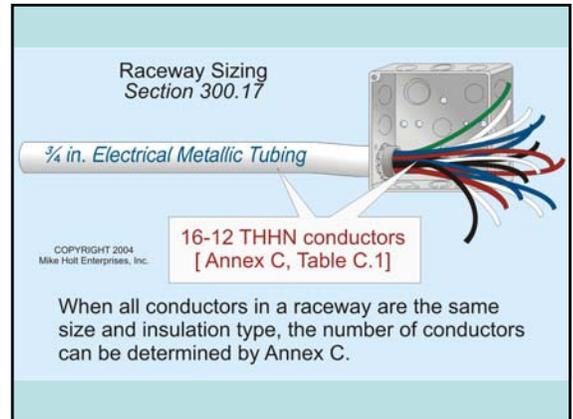
300.15 Boxes or Conduit Bodies

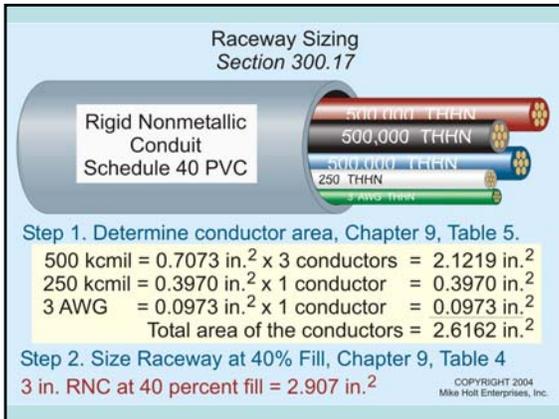
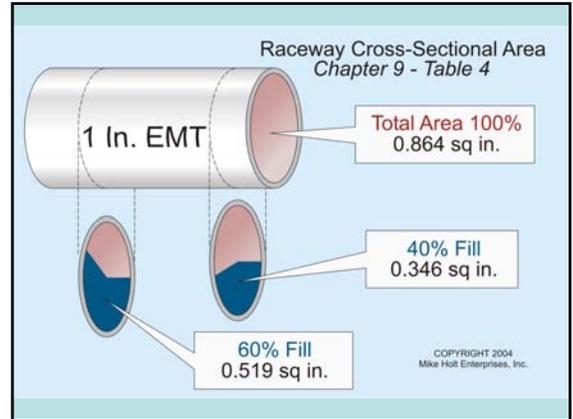
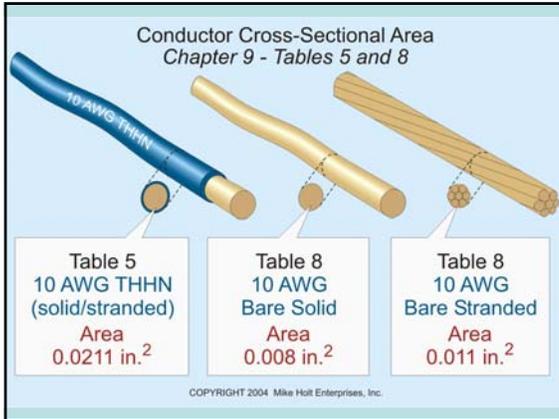
- (L) Handhole Enclosures. Where accessible only to qualified persons, a box or conduit body isn't required for conductors in handhole enclosures installed in accordance with 314.30.



300.17 Raceway Sizing

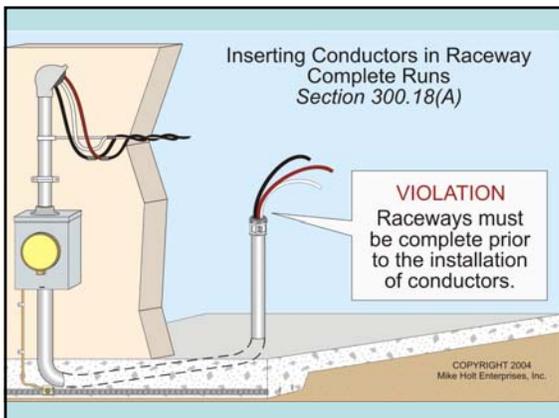
- Raceways must be large enough to permit the installation and removal of conductors without damaging the conductor's insulation.





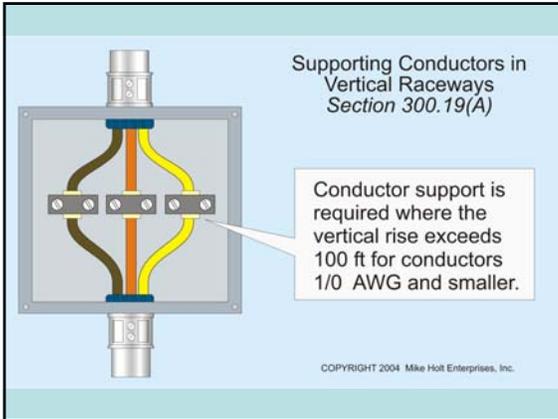
300.18 Inserting Conductors in Raceways

- (A) Complete Runs. To protect conductor insulation from abrasion during installation, raceways must be mechanically completed between the pulling points before conductors are installed. Ex: Short sections of raceways used for protection of cables from physical damage aren't required to be installed complete between outlet, junction, or splicing points.



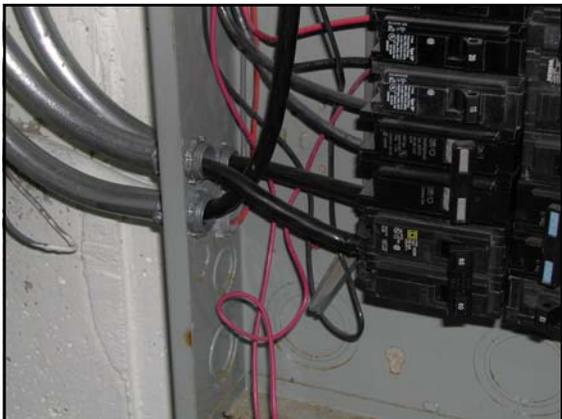
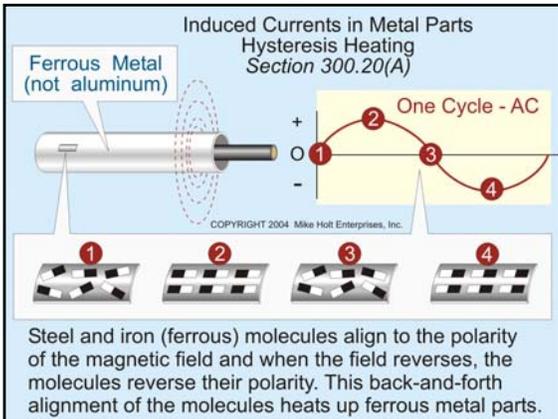
300.19 Supporting Conductors in Vertical Raceways

- (A) Spacing Intervals. If the vertical rise of a raceway exceeds the values of Table 300.19(A), the conductors must be supported at the top, or as close to the top as practical.



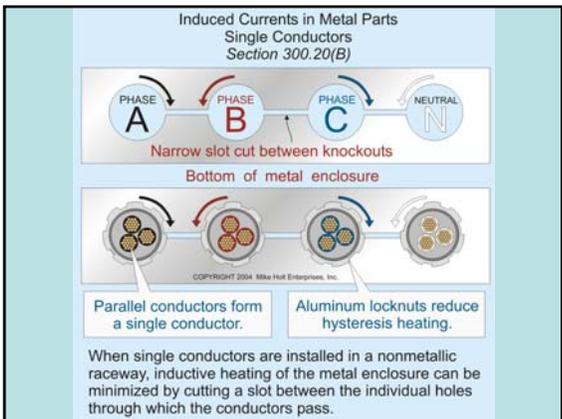
300.20 Induced Currents in Metal Parts

- (A) Conductors Grouped Together. To minimize induction heating of ferrous metallic raceways and enclosures, 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.



300.20 Induced Currents in Metal Parts

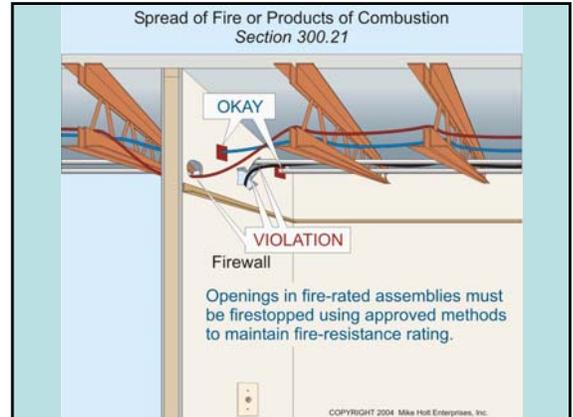
- (B) Single Conductors. When single conductors are installed in nonmetallic raceways as permitted in 300.5(I) Ex. 2, the inductive heating of the metal enclosure can be minimized by the use of aluminum locknuts and by cutting a slot between the individual holes through which the conductors pass. FPN: Because aluminum is a nonmagnetic metal, there will be no heating of aluminum metal parts due to hysteresis.



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 firestopped using methods approved by the AHJ to maintain the fire-resistance rating of the fire-rated assembly.



300.21

Spread of Fire or Products of Combustion

- 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.

300.21

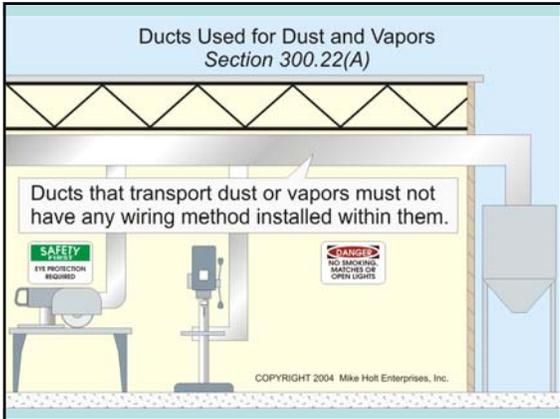
Spread of Fire or Products of Combustion

- FPN: 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.

300.22

Ducts, Plenums, and 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.

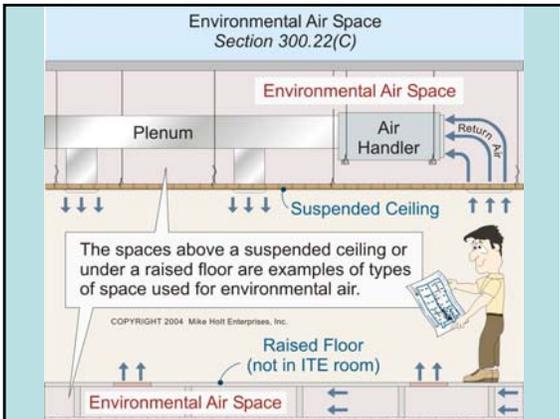


300.22
Ducts, Plenums, and Air-Handling Spaces

- (B) Ducts or Plenums Used for Environmental Air. Where necessary for their direct action upon, or sensing of the contained air...

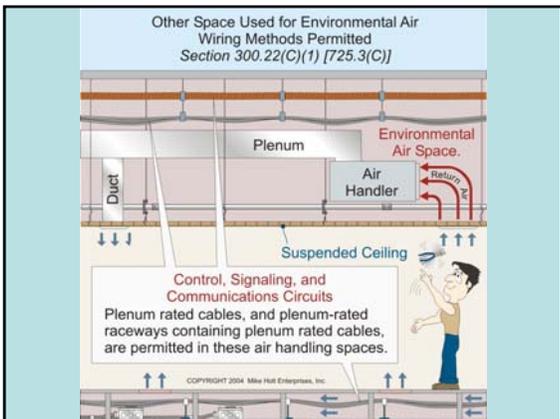
300.22
Ducts, Plenums, and Air-Handling Spaces

- (C) Space Used for Environmental Air.
- FPN: The spaces above a suspended ceiling or below a raised floor that is used for environmental air, are examples of the type of space to which this section applies.



300.22
Ducts, Plenums, and Air-Handling Spaces

- (C) Space Used for Environmental Air.
- (1) Wiring Methods Permitted. EMT, RMC, IMC, armored cable, metal clad cable without a nonmetallic cover, and flexible metal conduit can be installed in other environmental air spaces.



300.22

Ducts, Plenums, and Air-Handling Spaces

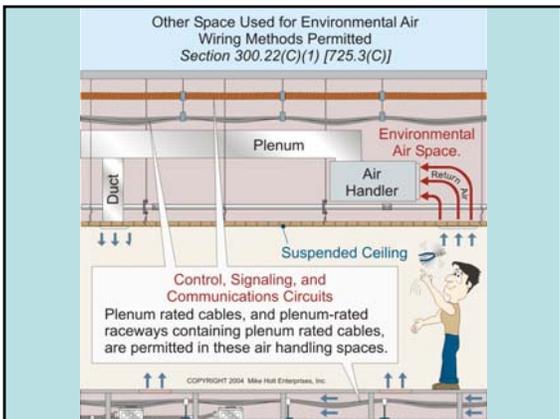
- (C) Space Used for Environmental Air.
- (1) Wiring Methods Permitted.
- Where accessible, surface metal raceway, metal wireway with metal covers, or solid bottom metal cable tray with solid metal covers can be installed in other environmental air spaces.



300.22

Ducts, Plenums, and Air-Handling Spaces

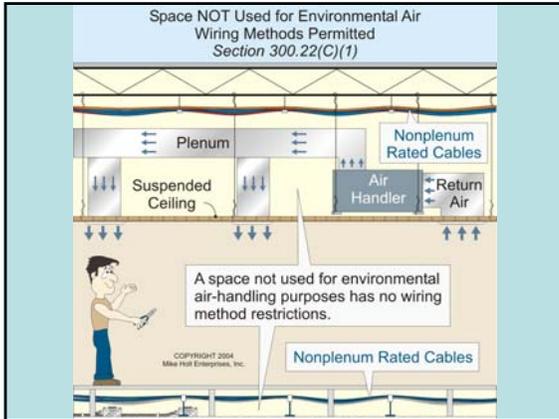
- (C) Space Used for Environmental Air.
- (1) Wiring Methods Permitted.
- However, control, signaling, and communications cables and plenum-rated nonmetallic raceways installed in spaces used for environmental air must be plenum rated.



300.22

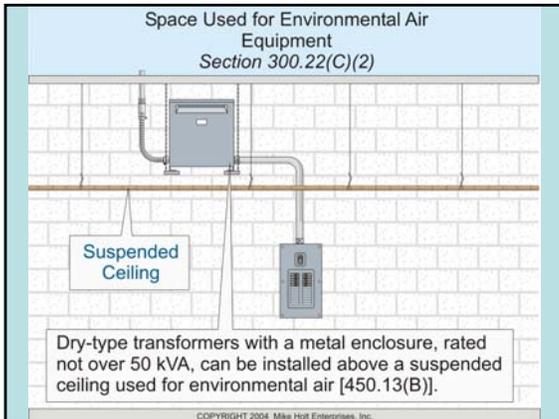
Ducts, Plenums, and Air-Handling Spaces

- (C) Space Used for Environmental Air.
- Any wiring method suitable for the location can be installed in a space not used for environmental air-handling, such as above suspended ceiling or raised floor.



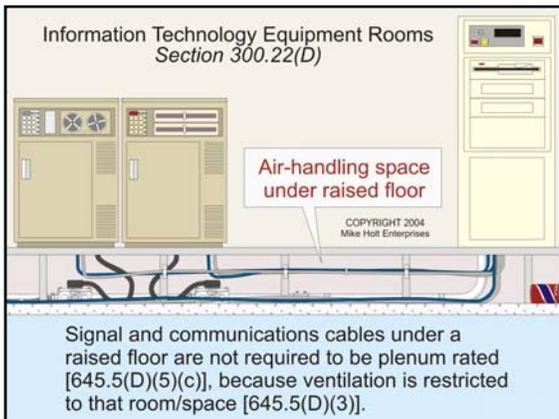
300.22 Ducts, Plenums, and Air-Handling Spaces

- (C) Space Used for Environmental Air.
- (2) Equipment. Electrical equipment with a metal enclosure is permitted in other environmental air spaces, unless prohibited elsewhere in this Code.



300.22 Ducts, Plenums, and Air-Handling Spaces

- (D) Information Technology Equipment Room. Wiring under a raised floor in an information technology room must comply with 645.5(D).



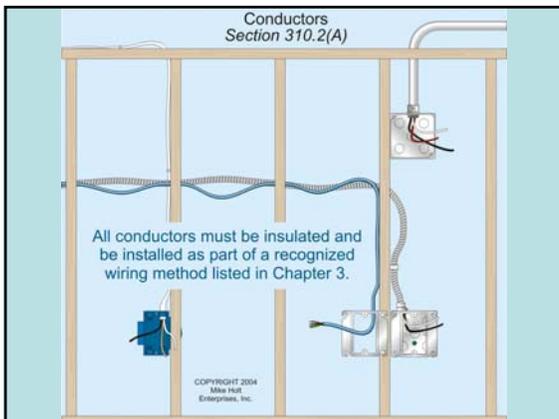
Article 310 Conductors for General Wiring

310.1 Scope

- Article 310 contains the general requirements for conductors, such as insulation markings, ampacity ratings, and their use.
- This article doesn't apply to conductors that are an integral part of cable assemblies, cords, or equipment.

310.2 Conductors

- (A) Insulation. All conductors must be insulated, and they must be installed as part of a recognized wiring method listed in Chapter 3.
- Ex: Where permitted, bare equipment grounding or bonding conductors are not required to be insulated.

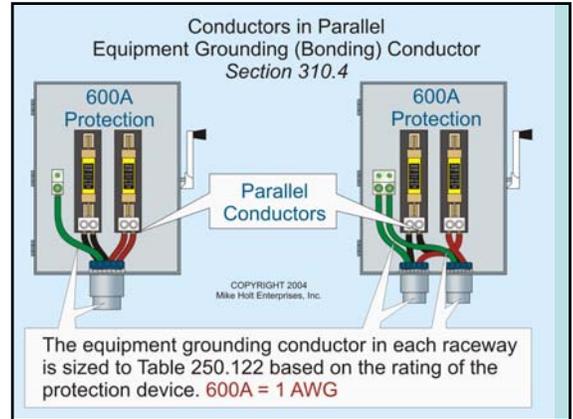
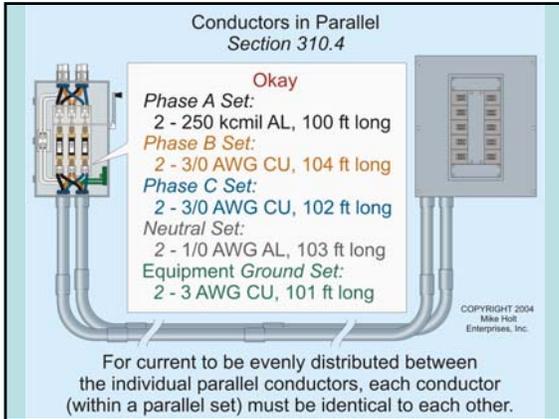


310.4 Conductors in Parallel

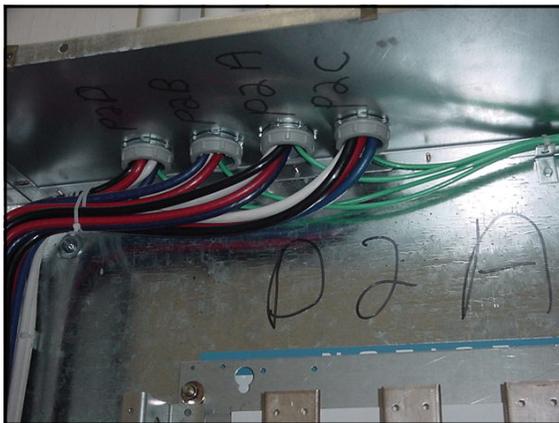
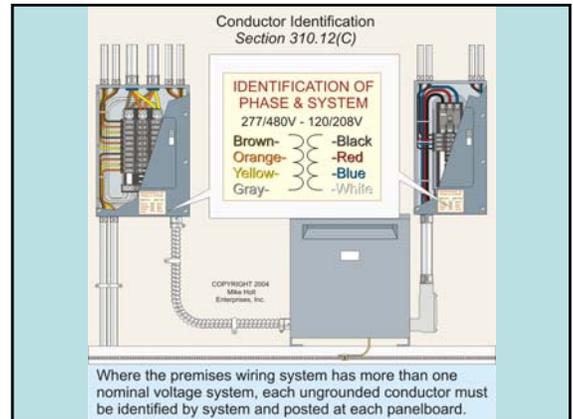
- Ungrounded and grounded conductors sized 1/0 AWG and larger can be connected in parallel.
- The minimum 1/0 AWG conductor size rule doesn't apply to equipment grounding (bonding) conductors.

310.4 Conductors in Parallel

- All conductors within a parallel set must:
 - (1) Be the same length.
 - (2) Be made of the same conductor material.
 - (3) Be the same size in circular mil area.
 - (4) Use the same insulation material.
 - (5) Terminate in the same method.



- ### 310.12 Conductor Identification
- (A) Grounded Neutral Conductor. The grounded neutral conductor must be identified in accordance with 200.6.
 - (B) Equipment Grounding (Bonding) Conductor. The equipment grounding (bonding) conductor must be identified in accordance with 250.119.
 - (C) Ungrounded Conductors. Ungrounded conductors must be clearly distinguishable from grounded neutral and equipment grounding (bonding) conductors.



- ### 310.13 Conductor Construction
- -2 90°C in wet locations No H 60°C insulation rating
 - H 75°C insulation rating HH 90°C insulation rating
 - N Nylon outer cover R Thermoset insulation
 - T Thermoplastic insulation U Underground
 - W Wet or damp locations
 - X Cross-linked polyethylene

Conductor Properties
Table 310.13

T hermoplastic
 HH = (two H) 90°C Insulation
 Nylon Jacket or equivalent
 10 AWG THHN 600V

T hermoplastic
 H = (one H) 75°C Insulation
 W et Locations
 10 AWG THW 600V

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Table 310.13 contains conductor insulation information, such as operating temperature and applications. These conductors can be used in any Chapter 3 wiring method.

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).

310.15 Conductor Ampacity

- (A) General Requirements
- (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).

Conductor Ampacity - Lower Rating

Section 310.15(A)(2)
3/0 THHN (rated 225A at 90°C)

Temperature 86°F $225A \times 1.0 = 225A$	Temperature 108°F $225A \times 0.87 = 196A$
---	---

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3/0 THHN rated 196A in ambient temperature of 108°F.

Where two ampacity ratings apply to a single conductor length, the lower ampacity must be used for the entire circuit.

310.15 Conductor Ampacity

- (A) General Requirements
- (2) Conductor Ampacity - Lower Rating.
- Ex: When different ampacities apply to a length of conductor, the higher ampacity is permitted for the entire circuit if the reduced ampacity length does not exceed 10 ft and its length doesn't exceed 10 percent of the length of the higher ampacity.

Conductor Ampacity - Higher Rating

Section 310.15(A)(2) Ex

Higher Ampacity
12 AWG = 30A

Lower Ampacity
12 AWG = 15A
(30A x 0.5)

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The higher ampacity can be used if the length of the lower ampacity is not more than 10 ft, and it is not longer than 10 percent of the higher ampacity length.

310.15 Conductor Ampacity

- (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.

Conductor Ampacity - Table 310.16 Correction and Adjustment Section 310.15(B)

This raceway contains only
3 current-carrying conductors



Table 310.16 ampacity is based on an ambient temperature of not over 86°F and no more than 3 current-carrying conductors bundled together.

Conductor Ampacity Adjustment

Ambient
Temperature



If the ambient temperature is above 86°F, the conductor ampacity decreases.

Conductor
Bundling



If the number of current-carrying conductors exceeds 3, the conductor ampacity decreases.

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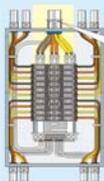
310.15 Conductor Ampacity

- (B) Ampacity Table.
- (2) Ampacity Adjustment
- (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 stacked or bundled in lengths exceeding 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).

310.15 Conductor Ampacity

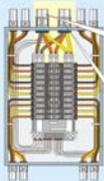
- (B) Ampacity Table.
- (2) Ampacity Adjustment
- (a) Conductor Bundle. Each current-carrying conductor of a paralleled set of conductors must be counted as a current-carrying conductor.

Conductor Ampacity Adjustment - Paralleled Conductors Table 310.15(B)(2)(a)



Two Parallel Sets
Six current-carrying conductors
(Seven if neutral is current-carrying)

Each current-carrying conductor
of a paralleled set of conductors
must be counted as a current-carrying conductor.



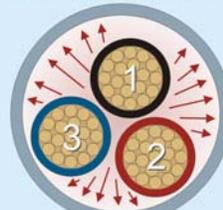
Parallel Set 1
Three current-carrying conductors
(Four if neutral is current-carrying)

Parallel Set 2
Three current-carrying conductors
(Four if neutral is current-carrying)

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Conductor Ampacity - Table 310.16 Adjustment Factor Table 310.15(B)(2)(a)

No Ampacity Adjustment
Three or fewer Conductors



Conductors have more surface
area for heat dissipation.

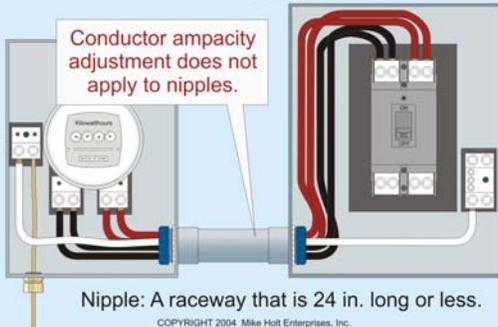
Ampacity Adjustment
Factor = 70%



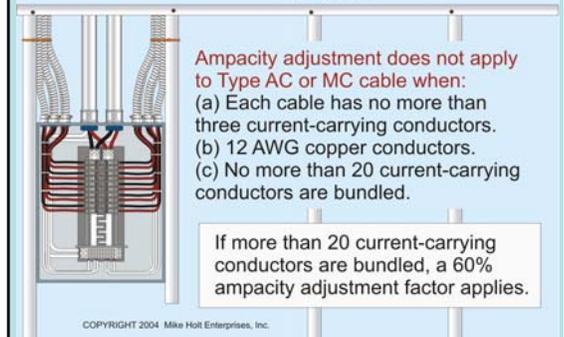
Bundled conductors
have heat held in
by other conductors.

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Conductor Ampacity - Table 310.16
Adjustment Factor
Table 310.15(B)(2)(a) Ex 3



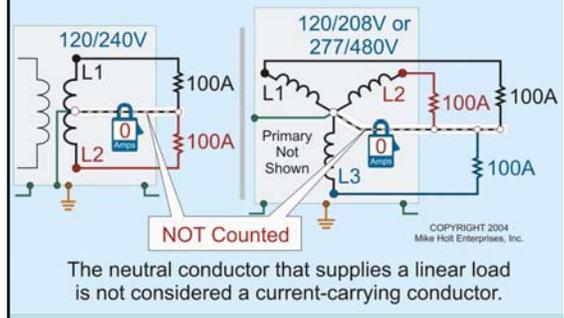
Conductor Ampacity - Table 310.16
Adjustment Factor - AC and MC Cables
Section 310.15(B)(2)(a) Ex 5



310.15 Conductor Ampacity

- (B) Ampacity Table.
- (4) Neutral Conductor
- (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.

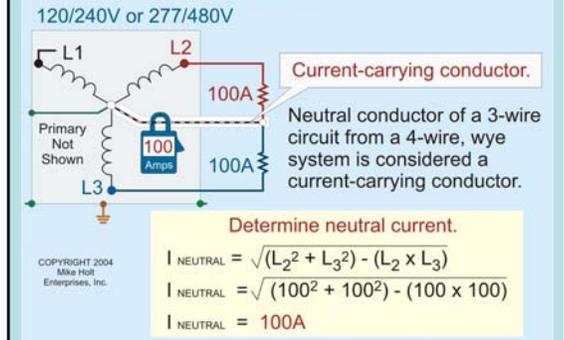
Neutral Conductors of
Balanced Circuits
Section 310.15(B)(4)(a)



310.15 Conductor Ampacity

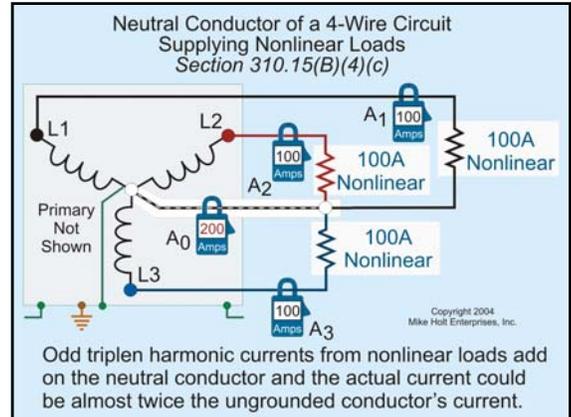
- (B) Ampacity Table.
- (4) Neutral Conductor
- (b) 3-Wire Circuits. The neutral conductor of a 3-wire circuit from a 4-wire three-phase 120/208V or 277/480V wye-connected system is considered a current-carrying conductor.

Neutral Conductor of a 3-Wire Circuit
From a Wye 4-Wire System
Section 310.15(B)(4)(b)



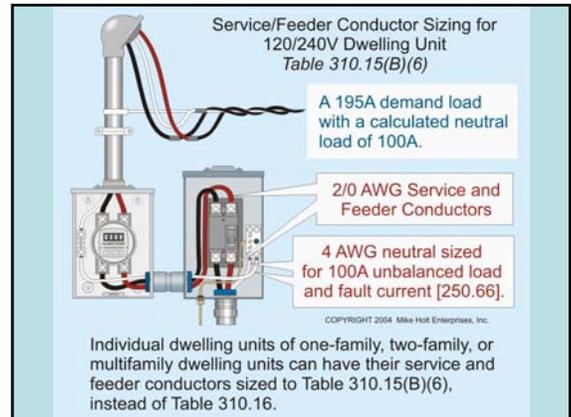
310.15 Conductor Ampacity

- (B) Ampacity Table.
- (4) Neutral Conductor
- (c) Wye 4-Wire Circuits That Supply Nonlinear Loads. The neutral conductor of a 4-wire three-phase circuit is considered a current-carrying conductor where the major portion of the neutral load consists of nonlinear loads.



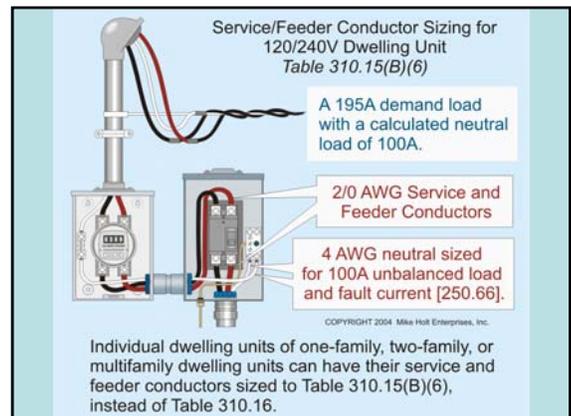
310.15 Conductor Ampacity

- (B) Ampacity Table.
- (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 (including neutral conductors) that serve as the main power feeder.



310.15 Conductor Ampacity

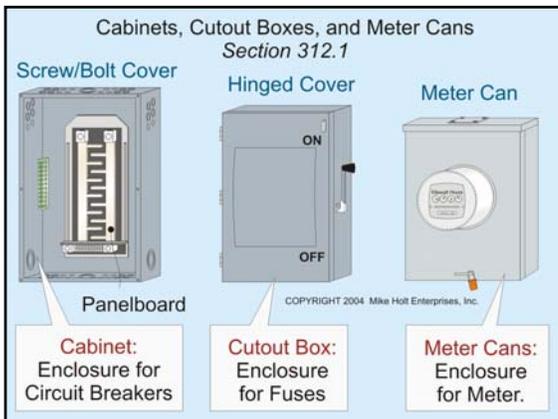
- (B) Ampacity Table.
- (6) Dwelling Unit Feeder/Service Conductors.
- Grounded Neutral Conductor Sizing. Table 310.15(B)(6) can be used to size the grounded neutral conductor of a 3-wire single-phase 120/240V service or feeder that serve as the main power feeder based on the feeder calculated load in accordance with Article 220.



Article 312 Cabinets, Cutout Boxes, and Meter Socket Enclosures

312.1 Scope

- Article 312 covers the installation and construction specifications for cabinets, cutout boxes, and meter socket enclosures.



312.2 Damp, Wet, or Hazardous (Classified) Locations

- (A) Damp and Wet Locations. Enclosures in damp or wet locations must prevent moisture or water from entering or accumulating within the enclosure, and must be weatherproof. When the enclosure is surface mounted in a wet location, the enclosure must be mounted with not less than a ¼ in. air space between it and the mounting surface.

312.2 Damp, Wet, or Hazardous (Classified) Locations

- (A) Damp and Wet Locations. Where raceways or cables enter above the level of uninsulated live parts of an enclosure in a wet location, a fitting listed for wet locations must be used for termination.

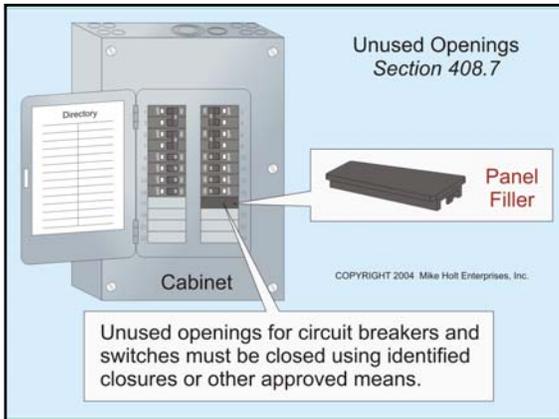


312.3 Installed in Walls

- Cabinet or cutout boxes installed in walls of concrete, tile, or other noncombustible material must be installed so that the front edge of the enclosure is set back no more than $\frac{1}{4}$ in. from the finished surface.
- In walls constructed of wood or other combustible material, cabinet or cutout boxes must be flush with the finished surface or project outward.

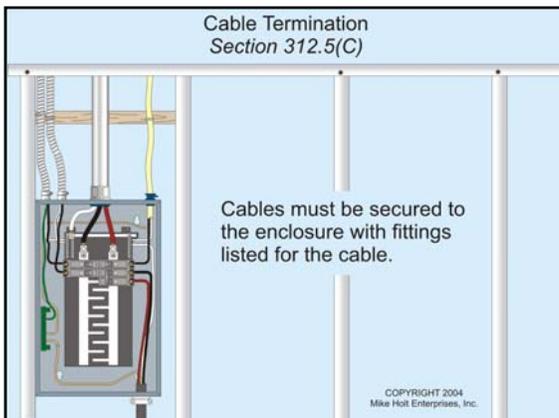
312.5 Enclosures

- (A) Unused Openings.
- Unused openings for circuit breakers must be closed by means that provide protection substantially equivalent to the wall of the enclosure [408.7].



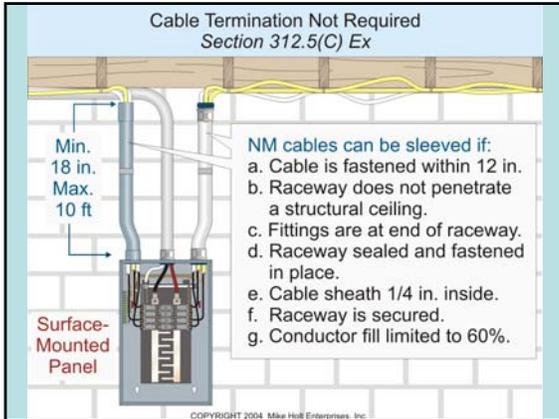
312.5 Enclosures

- (C) Cable Termination. Cables must be secured to the enclosure with fittings designed and listed for the cable. See 300.12 and 300.15.



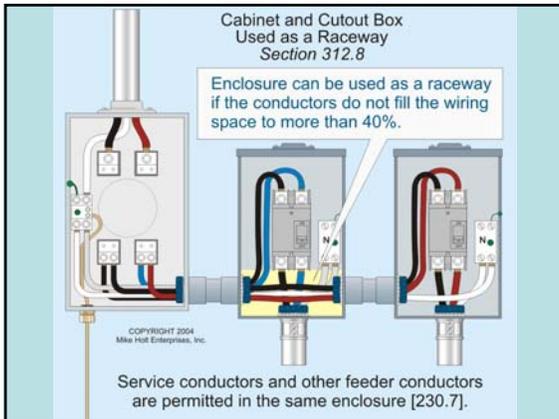
312.5 Enclosures

- (C) Cable Termination.
- Ex: Cables with nonmetallic sheaths aren't required to be secured to the enclosure if the cables enter the top of a surface-mounted enclosure through a nonflexible raceway not less than 18 in. or more than 10 ft long, if all of the following conditions are met:



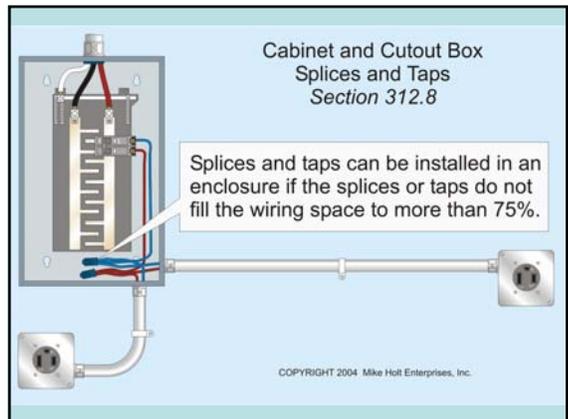
312.8 Used for Raceway and Splices

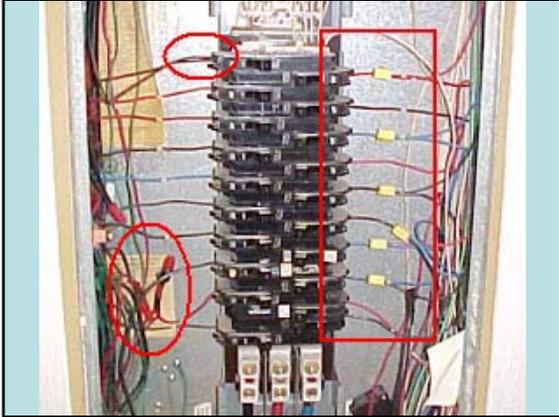
- Cabinets, cutout boxes and meter socket enclosures can be used as a raceway for conductors that feed through if the conductors do not fill the wiring space at any cross section to more than 40 percent.



312.8 Used for Raceway and Splices

- Splices and taps can be installed in cabinets, cutout boxes, or meter socket enclosures if the splices or taps do not fill the wiring space at any cross section to more than 75 percent.

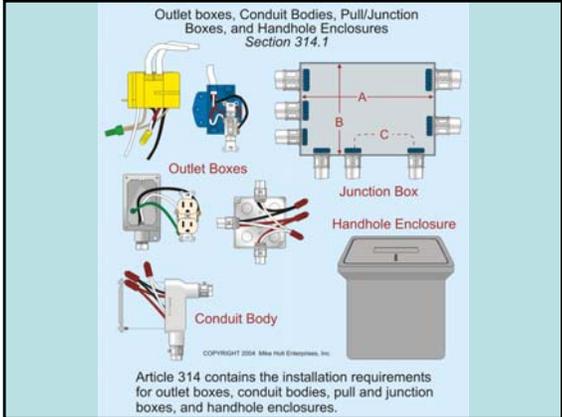




Article 314 Outlet, Pull/Junction Boxes, Conduit Bodies, and Handhole Enclosures

314.1 Scope

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



314.3 Nonmetallic Boxes

- Nonmetallic boxes can only be used with nonmetallic cables and raceways.
- Ex. 1: Metal raceways and metal cables can be used with nonmetallic boxes, if an internal bonding means is provided in the box between all metal entries.

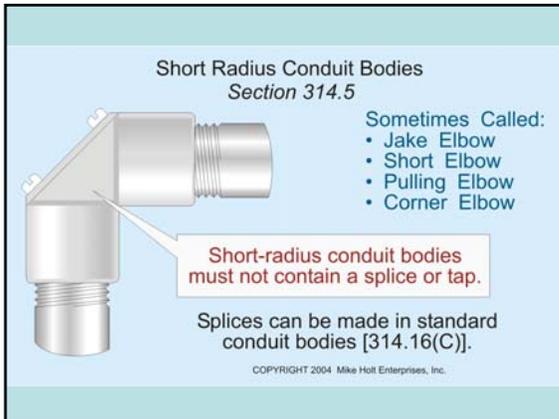


314.4 Metal Boxes.

- All metal boxes must be bonded to an effective ground-fault current path in accordance with Article 250 [250.4(A)(3)].

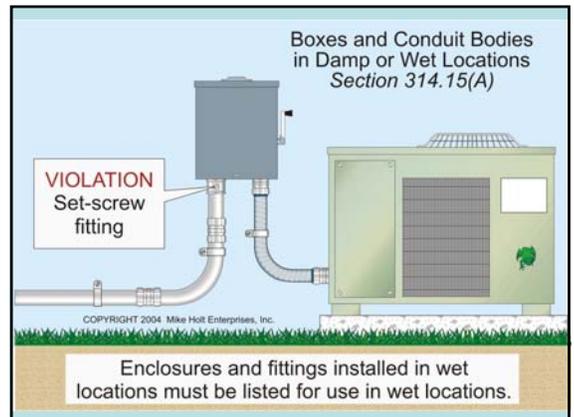
314.5 Short-Radius Conduit Bodies

- Short-radius conduit bodies, such as capped elbows, handy ells, and service-entrance elbows must not contain any splices or taps.



314.15 Damp, Wet, or Hazardous (Classified) Locations

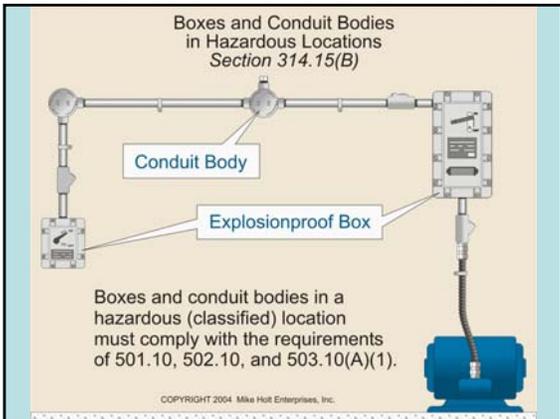
- (A) Damp and Wet Locations. Boxes and conduit bodies in damp or wet locations must prevent moisture or water from entering or accumulating within the enclosure.
- Boxes, conduit bodies, and fittings installed in wet locations must be listed for use in wet locations.





314.15 Damp, Wet, or Hazardous (Classified) Locations

- (B) Hazardous (Classified) Locations. Boxes and conduit bodies installed in hazardous (classified) locations must comply with 501.10, 502.10, and 503.10(A)(1).

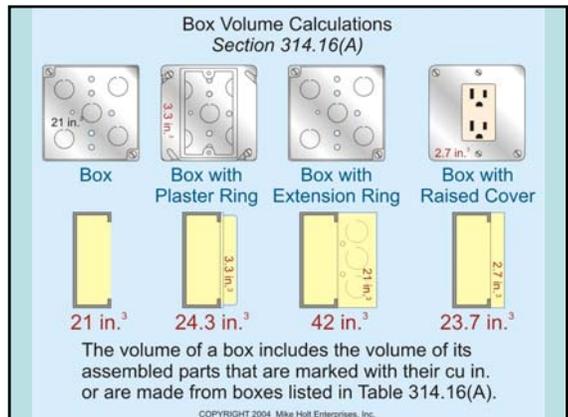


314.16 Number of 6 AWG and Smaller Conductors in Boxes and Conduit Bodies

- Boxes containing 6 AWG and smaller conductors must be sized to provide sufficient free space for all conductors, devices and fittings.
- The requirements for sizing of boxes and conduit bodies containing conductors 4 AWG and larger are contained in 314.28.

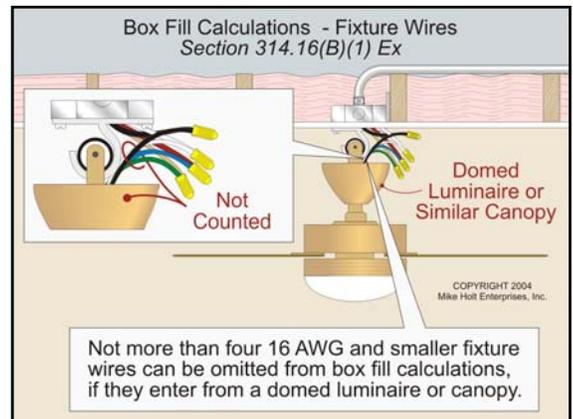
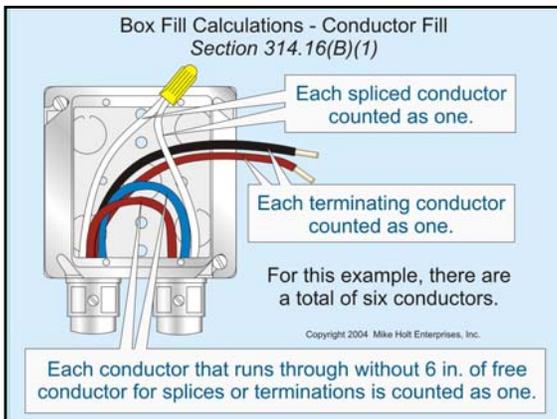
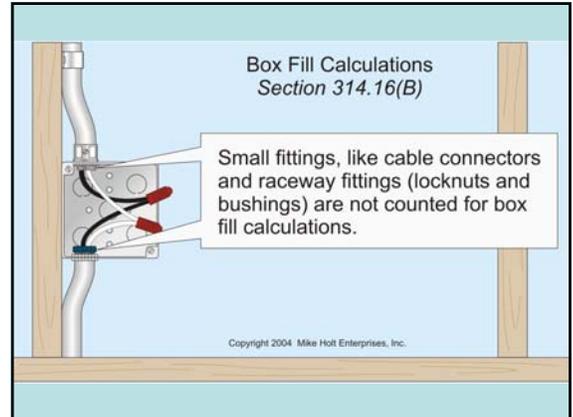
314.16 Number of 6 AWG and Smaller Conductors in Boxes and Conduit Bodies

- (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 or are made from boxes listed in Table 314.16(A).



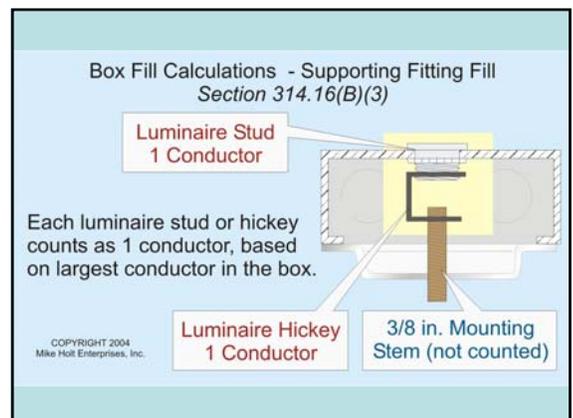
314.16 Number of 6 AWG and Smaller Conductors in Boxes and Conduit Bodies

- (B) Box Fill Calculations. The calculated conductor volume is 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.



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

- (B) Box Fill Calculations.
- (2) Cable Clamp Fill. 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 the box aren't counted.



Box Fill Calculations - Device Yoke Fill Section 314.16(B)(4)

Each device yoke counts as two conductors, based on the largest conductor terminating on the device.

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Box Fill Calculations - Bonding Conductor Fill Section 314.16(B)(5)

One or more equipment grounding (bonding) conductors count as one conductor.

An isolated grounding (bonding) conductor counts as an additional conductor.

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Box Fill Calculations Example Section 314.16(B)

How many 14 AWG conductors can be added?

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Step 1. Volume of box/ring: $30.3 + 3.6 \text{ cu in.} = 33.9 \text{ cu in.}$
 Step 2. Volume of existing conductors/devices = 22.5 cu in.
 Step 3. Space remaining: $33.9 - 22.5 = 11.4 \text{ cu in.}$
 Step 4. Number of 14 AWG added: $11.4/2.0 \text{ cu in.} = 5$

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

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

Conduit Body - Conductor Splices Section 314.16(C)(2)

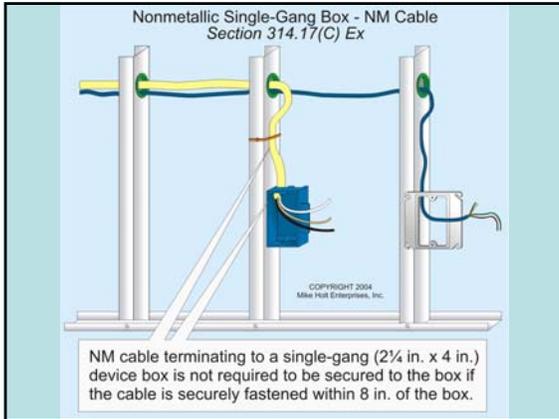
Conductors 6 AWG and smaller can be spliced in a conduit body if the cu in. capacity is marked on the conduit body.

Six 12 AWG Conductors (15 cu in./2.25 cu in.)

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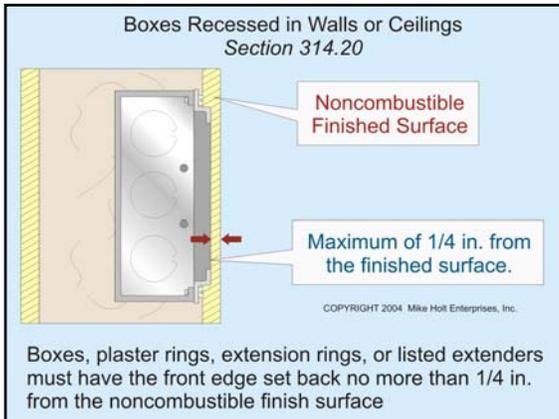
314.17 Conductors That Enter Boxes or Conduit Bodies

- (C) Nonmetallic Boxes and Conduit Bodies. Raceways and cables must be securely fastened to nonmetallic boxes or conduit bodies by fittings designed for the wiring method.
- Ex: Type NM cable terminating to a single-gang device box isn't required to be secured to the box if the cable is securely fastened within 8 in. of the box.



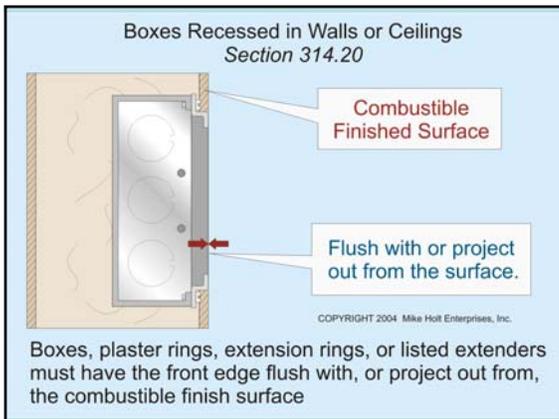
314.20
Boxes Recessed in Walls or Ceilings

- Boxes having flush-type covers recessed in walls or ceilings of noncombustible material must have the front edge of the box, plaster ring, extension ring, or listed extender set back no more than 1/4 in. from the finished surface.



314.20 Boxes Recessed in Walls or Ceilings

- In walls or ceilings constructed of wood or other combustible material, boxes must be installed so the front edge of the enclosure, plaster ring, extension ring, or listed extender is flush with, or projects out from, the finished surface.



314.21 Repairing Gaps Around Boxes

- Gaps around boxes recessed in plaster, drywall, or plasterboard having a flush-type cover, must be repaired so there will be no gap greater than 1/8 in. at the edge of the box.

Repairing Gaps Around Outlet Boxes
Section 314.21

Gaps around boxes recessed in plaster, drywall, or plasterboard having flush-type covers, must be repaired so there will be no gap greater than 1/8 in. at the edge of the box.

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314.22 Surface Extensions

- Surface extensions can only be made from an extension ring mounted over a flush-mounted box.

Surface Extensions
Section 314.22

Surface extensions from a flush box must be made from an extension ring that is installed over the flush box.

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314.22 Surface Extensions

- Ex: A surface extension can be made from the cover of a flush-mounted box if the cover is designed so it's unlikely to fall off if the mounting screws become loose.
- The surface extension wiring method must be flexible to permit the removal of the cover and provide access to the box interior, and bonding continuity must be independent of the connection between the box and the cover.

Surface Extension from a Cover
Section 314.22 Ex

Extension from cover is permitted if:

- cover is designed not to fall off
- a flexible wiring method is used
- the grounding (bonding) connection must be independent from the cover

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314.23 Support of Boxes and Conduit Bodies

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

314.23

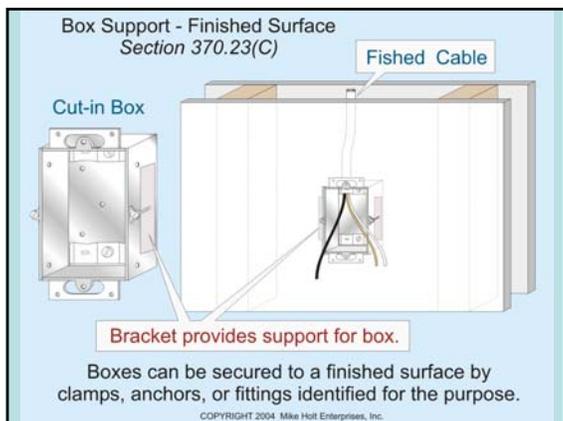
Support of Boxes and Conduit Bodies

- (B) Structural Mounting. Boxes can be supported 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.

314.23

Support of Boxes and Conduit Bodies

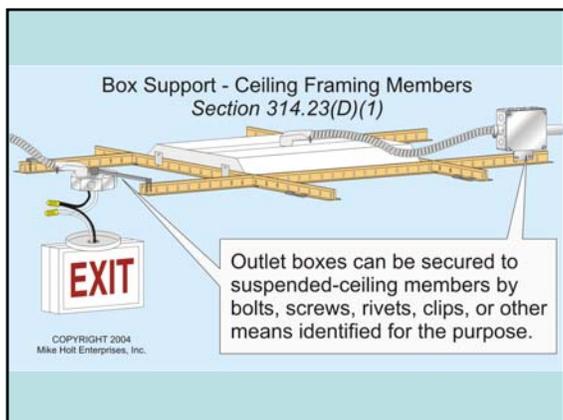
- (C) Finished Surface Support. Boxes can be secured to drywall or plaster walls or ceilings by clamps, anchors, or fittings identified for the purpose.



314.23

Support of Boxes and Conduit Bodies

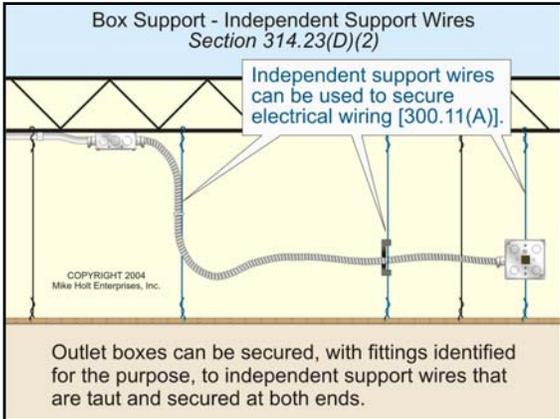
- (D) Suspended-Ceiling Support.
- (1) Ceiling-Framing Members. An outlet box can be secured to suspended-ceiling framing members by bolts, screws, rivets, clips, or other means identified for the suspended-ceiling framing member(s).



314.23

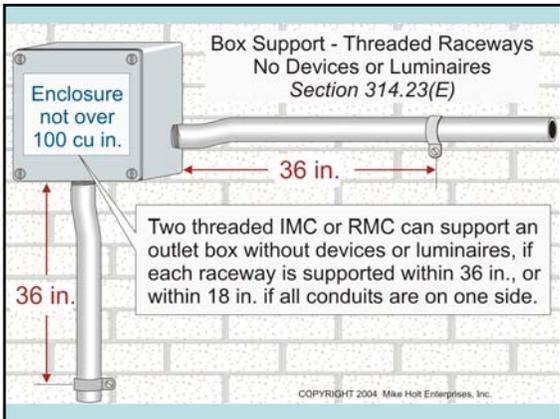
Support of Boxes and Conduit Bodies

- (D) Suspended-Ceiling Support.
- (2) Independent Support Wires. Outlet boxes can be secured, with fittings identified for the purpose, to independent support wires that are taut and secured at both ends [300.11(A)].



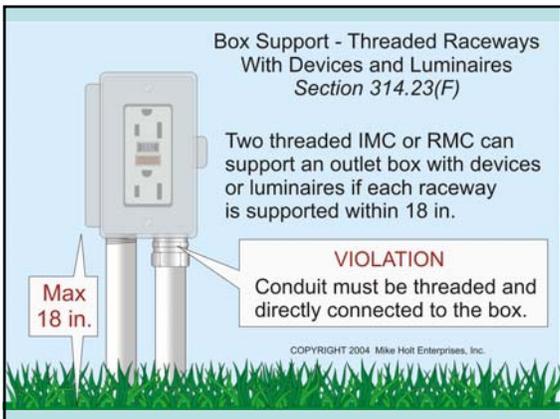
314.23
Support of Boxes and Conduit Bodies

- (E) Raceway Support - Boxes and Conduit Bodies Without Devices or Luminaires. Two IMC or RMC threaded wrenchtight can be used to support an outlet box that does not 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.



314.23
Support of Boxes and Conduit Bodies

- (F) Raceway Support - Boxes and Conduit Bodies with Devices or Luminaires. Two IMC or RMC threaded wrenchtight can be used to support an outlet box containing devices or luminaires, if each raceway is supported within 18 in. of the box.



314.23
Support of Boxes and Conduit Bodies

- (H) Pendant Boxes
- (1) Flexible Cord. Boxes can be supported from a cord that is connected to fittings that prevent tension from being transmitted to joints or terminals [400.10].

Box Support - Pendant Cord
Section 314.23(H)(1)

Boxes can be supported from a cord that is connected to fittings so that tension is not transmitted to joints or terminals.



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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. See 410.12.

Covers and Canopies
Section 314.25

A faceplate or luminaire can cover an outlet box.

Blank cover plates can cover an outlet box.

When an installation is complete, each outlet box must be provided with a cover, faceplate, fixture canopy, lampholder, or similar device.

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314.25 Covers and Canopies

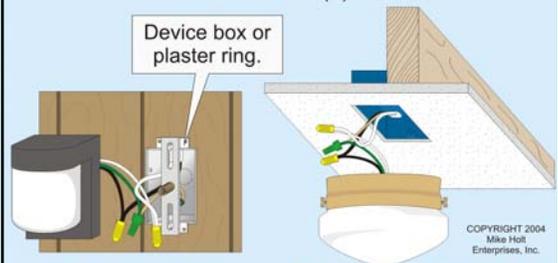
- (A) Nonmetallic or Metallic. Nonmetallic covers or plates are permitted on any box, but metallic faceplates, where used, must be bonded to an effective ground-fault current path in accordance with 250.110 [250.4(A)(3)].

314.27 Outlet Box

- (A) Boxes at Luminaire. Lighting outlet boxes must be designed for the purpose and must be installed for every luminaire. Device outlet boxes are only to be used for the support of switches or receptacles, not luminaires or lampholders.
- Ex: A wall-mounted luminaire weighing no more than 6 lbs can be supported to a device box or plaster ring secured to a box.

Device Outlet Box - Luminaire Support
Section 314.27(A) Ex

Device box or plaster ring.



Wall-Mount - OKAY

Ceiling-Mount - VIOLATION

A wall-mounted luminaire (not more than 6 lbs) can be supported to a device box or plaster ring.

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314.27 Outlet Box

- (B) Luminaire Weight. Lighting outlet boxes can support luminaires that weigh up to 50 lbs.

Outlet Box - Luminaire Weight Section 314.27(B)

Lighting outlet boxes can support luminaires that weigh up to 50 lbs.

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Luminaires over 50 lbs must be supported independently.



314.27 Outlet Box

- (C) Floor Box. Floor boxes must be specifically listed for the purpose.

Floor Outlet Box Section 314.27(C)

Floor outlet boxes must be listed for the purpose.

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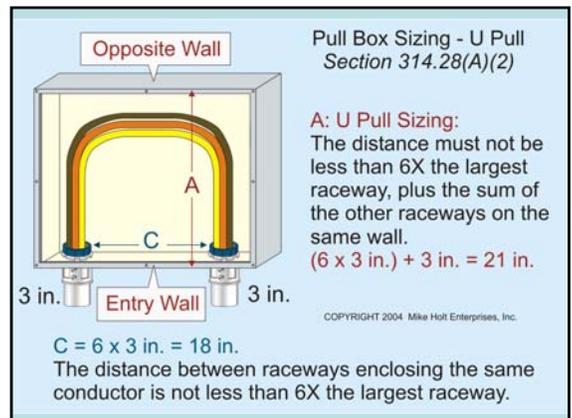
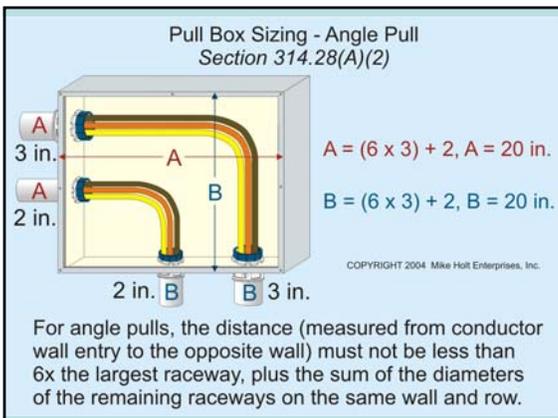
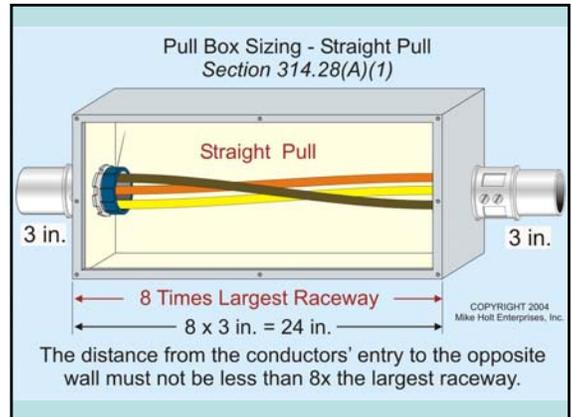
314.27 Outlet Box

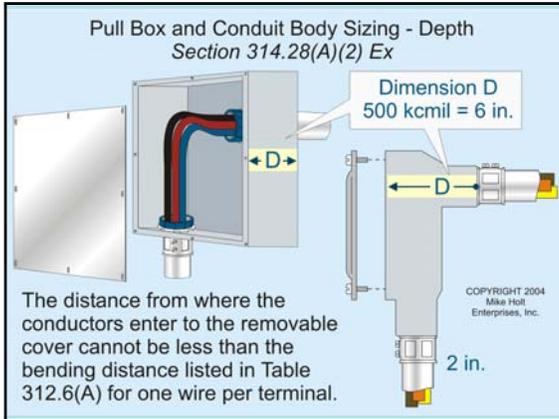
- (D) Ceiling Paddle Fan Box. Outlet boxes for a ceiling paddle fan must be listed and marked as suitable for the purpose, and must not support a fan weighing more than 70 lbs.



314.28 Boxes and Conduit Bodies for Conductors 4 AWG and Larger

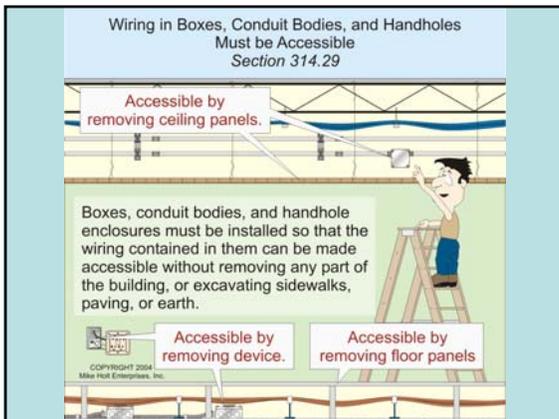
- Boxes and conduit bodies containing conductors 4 AWG and larger must be sized so the conductor insulation will not be damaged.





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.



314.30 Handhole Enclosures

- Handhole enclosures must be designed and installed to withstand all loads likely to be imposed.

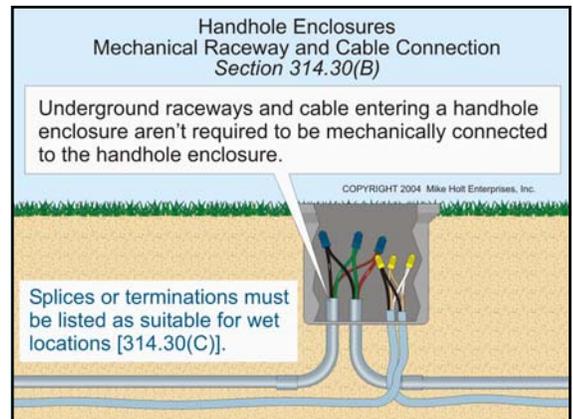


314.30 Handhole Enclosures

- (A) Size. Handhole enclosures must be sized in accordance with 314.28(A).
- For handhole enclosures without bottoms, the measurement to the removable cover is taken from the end of the conduit or cable assembly.

314.30 Handhole Enclosures

- (B) Mechanical Raceway and Cable Connection. Underground raceways and cable entering a handhole enclosure aren't required to be mechanically connected to the handhole enclosure.



314.30 Handhole Enclosures

- (C) Handhole Enclosures Without Bottoms. All splices or terminations must be listed as suitable for wet locations [110.14(B)].

314.30 Handhole Enclosures

- (D) Covers. Handhole enclosure covers must have an identifying mark or logo that prominently identifies the function of the enclosure, such as "electric."



314.30 Handhole Enclosures

- (D) Covers. Handhole enclosure covers must require the use of tools to open, or they must weigh over 100 lbs.
- Metal covers and other exposed conductive surfaces must be bonded to an effective ground-fault current path in accordance with 250.96(A).



Article 320 Armored Cable

- Armored cable is an assembly of insulated conductors, 14 AWG through 1 AWG that are individually wrapped within waxed paper and contained within a flexible spiral metal sheath. Armored cable looks like flexible metal conduit.

320.1 Scope

- This article covers the use, installation, and construction specifications of armored cable, Type AC.

320.2 Definition

- Armored Cable. A fabricated assembly of conductors in a flexible metal sheath with an internal bonding strip in intimate contact with the armor for its entire length.

Armored Cable - Definition
Section 320.2

Waxed Paper Jute

Interlocked Spiral Metal Sheath

Bonding Strip

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Armored Cable: A fabricated assembly of conductors in a flexible metal sheath with an internal bonding strip in intimate contact with the armor for its entire length.

320.15 Exposed Work

- Exposed Type AC cable must closely follow the surface of the building finish or running boards. Type AC cable run on the bottom of floor or ceiling joists must be secured at every joist and not subject to physical damage.

AC Cable - Exposed Work
Section 320.15

Type AC cable run on the bottom of floor or ceiling joists must be secured at every joist and not subject to physical damage.

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320.17 Through or Parallel to Framing Members

- Type AC cable installed through or parallel to framing members or furring strips must be protected against physical damage from penetration by screws or nails by maintaining 1 ¼ in. of separation or by installing a suitable metal plate.

AC Cable - Through Framing
Section 320.17

A Bored Hole, [300.4(A)(1)]
1 ¼ in. or more,
No steel plate required

B Bored Hole, [300.4(A)(1)]
Less than 1 ¼ in.
Steel plate required

C Notch (if permitted)
[300.4(A)(2)]
Steel plate required

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AC Cable - Parallel to Framing Members and Furring Strips
Section 320.17

Cable must be at least 1 ¼ in. from the nearest edge of a framing member or furring strip, or be protected by a steel plate or sleeve [300.4(D)].

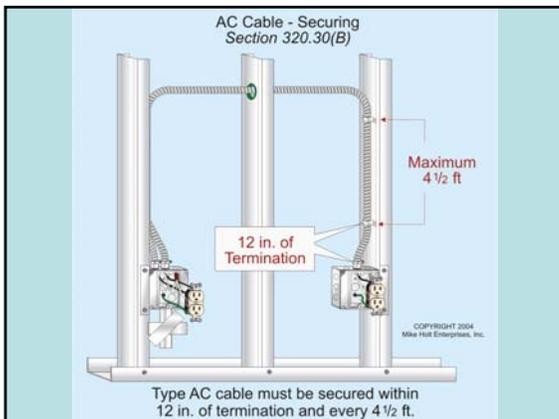
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320.30 Secured and Supported

- (A) General. Type AC cable must be supported and secured by staples, cable ties, straps, hangers, or similar fittings, designed and installed not to damage the cable.

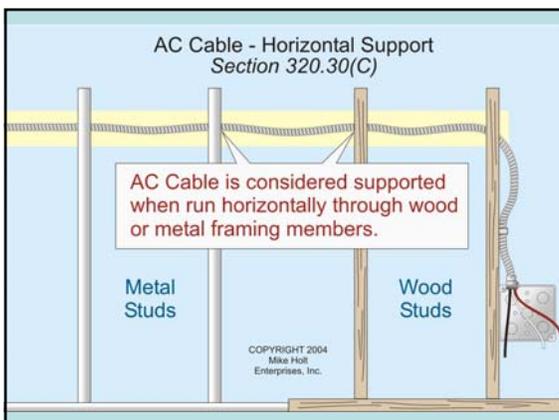
320.30 Secured and Supported

- (B) Securing. Type AC cable must be secured within 12 in. of every outlet box, junction box, cabinet, or fitting and at intervals not exceeding 4½ ft.



320.30 Secured and Supported

- (C) Supporting. Cables installed horizontally through wooden or metal framing members are considered supported where support doesn't exceed 4½ ft.

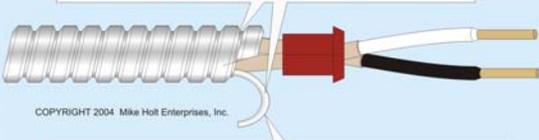


320.30 Secured and Supported

- (D) Unsupported Cables. Type AC cable can be unsupported where:
 - (1) Fished,
 - (2) For 2 ft long at terminals where flexibility is necessary, or
 - (3) For 6 ft from the last point of cable support or cable fitting, to a luminaire or electrical equipment within an accessible ceiling.

AC Cable - Equipment Grounding (Bonding)
Section 320.108

The combination of the interlocking armor of AC cable and the bonding strip makes the cable assembly suitable to serve as an effective ground-fault current path.



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Bonding strip can be cut off at the termination or it can be used to secure the anti-short bushing.

