Ohio Board of Building Standards
Building on the Code Education Series

Residential Code of Ohio
Electrical Requirements
September 27, 2013

Presentation Handout
Ohio Board of Building Standards

Building on the Code
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Residential Code of Ohio
Electrical Requirements
based on the 2011 National Electrical Code

Presentation By:
Ohio Chapter / International Association of Electrical Inspectors
Purpose of the National Electrical Code

• Primary purpose is electrical safety

• The purpose is described in NEC text as the “practical safeguarding of persons and property from the hazards arising from the use of electricity”

• Electrical installations installed in compliance with NEC rules minimize the hazards and reduce the risk of fires
Listed or Labeled Equipment

- Use listed or labeled equipment where available
- Many NEC rules specifically require listed equipment
- Third party, independent and qualified testing organization (Listing Agency)
- Internal parts of listed equipment need not be inspected except to detect alterations or damage

Article 100: Definitions

- **Approved**: “Acceptable to the authority having jurisdiction.”
- **Authority Having Jurisdiction (AHJ)**: “The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.”
Article 100: Definitions

- **Labeled**: “Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.”

- **Listed**: “Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or services meets identified standards or has been tested and found suitable for a specified purpose.”
Listed Electrical Equipment

Equipment or materials that have a label, symbol, or mark of a qualified electrical testing laboratory.

Listed electrical equipment serves as a basis for approval of electrical installations

Installation and Use

- Listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling [110.3(B)]
- Instructions sometimes accompany the product
- Instructions may be on the product
- Instructions also included in “Guide Card” information in UL Directories
Article 100: Definitions

• **Identified (as applied to equipment):** “Recognizable as suitable for the specific purpose, function, use, environment, application, etc., where described in a particular NEC requirement.”

  **Informational Note:** Some examples of ways to determine suitability of equipment for a specific purpose, environment, or application include investigations by a qualified testing laboratory (listing and labeling), an inspection agency, or other organizations concerned with product evaluation.

• **Equipment:** “A general term including material, fittings, devices, appliances, luminaires (fixtures), apparatus, and the like used as part of, or in connection with, an electrical installation.”

• **In Sight From (Within Sight From, Within Sight):** “Where the NEC specifies that one equipment shall be “in sight from,” “within sight from,” or “within sight of,” and so forth, another equipment, the specified equipment is to be visible and not more than 15 m (50 ft) distant from the other.”
Article 100: Definitions

- **Appliance:** “Utilization equipment, generally other than industrial, normally built in standardized sizes or types and is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, deep frying, and so forth.”

- **Overcurrent Protective Device, Branch-Circuit:** “A device capable of providing protection for service, feeder, and branch circuits and equipment over the full range of overcurrents between its rated current and its interrupting rating. Branch-circuit overcurrent protective devices are provided with interrupting ratings appropriate for the intended use but no less than 5,000 amperes.”

Article 100: Definitions

- **Device:** “A unit of an electrical system that carries or controls electric energy as its principal function.”

- **Fitting:** “An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical rather than an electrical function.”

- **Utilization equipment:** “Equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting, or similar purposes.”
Article 100: Definitions

• **Luminaire**: “A complete lighting unit consisting of a light source such as a lamp or lamps, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light.

• A lampholder itself is not a luminaire.”
Article 100: Definitions

- Location, Damp: “Locations protected from weather and not subject to saturation with water or other liquids but subject to moderate degrees of moisture. Examples of such locations include partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold-storage warehouses.”
Article 100: Definitions

- **Location, Dry:** “A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.”

- **Location, Wet:** “Installations under ground or in concrete slabs or masonry in direct contact with the earth; in locations subject to saturation with water or other liquids, such as vehicle washing areas; and in unprotected locations exposed to weather.”
Enclosure Types

- Outdoor enclosures are also suitable for use indoors if they meet the environmental conditions present

- Type 1 - Indoor Use
  - Type 1 enclosure may be marked “Indoor Use Only”

- Type 3R - Outdoor use, undamaged by the formation of ice on the enclosure
  - Type 3R enclosure may be marked “Rainproof”
110.12(A) Unused Openings to be Closed

- Unused openings, other than those intended for the operation of equipment, those intended for mounting purposes, or those permitted as part of the design for listed equipment, shall be effectively closed.

- Components used to provide this protection must be substantially equivalent to the wall of the equipment.

- Where metallic plugs or plates are used with nonmetallic enclosures, they shall be recessed at least 6 mm (¼ in.) from the outer surface of the enclosure.
408.7 Unused Openings

• Unused openings for circuit breakers and switches shall be closed using identified closures, or other approved means that provide protection substantially equivalent to the wall of the enclosure
  - Install filler plates for unused circuit breaker openings
  - Install seals in unused knockout openings in panelboards, boxes, wireways and other enclosures
• Install covers on all junction boxes, conduit bodies, and enclosures

Conductor Terminals

• Connection of conductors to terminal parts shall ensure a thoroughly good connection without damaging the conductors
• Connections shall be made by means of pressure connectors (including set-screw type), solder lugs, or splices to be flexible leads
• Connection by means of wire binding screws or studs and nuts having upturned lugs, or equivalent shall be permitted for 10 AWG or smaller conductors
• Terminals for more than one conductor and terminals used to connect aluminum shall be so identified
Appliance and Utilization Terminals

- Most terminals, unless marked otherwise, are suitable for use only with copper wire
- Marking for other wire such as aluminum may be abbreviated “AL-CU”
- Unless noted otherwise, termination provisions are based on the use of 60°C insulated conductors in circuits rated 100 amperes or less and 75°C in higher rated circuits
- Conductors with higher temperature rated insulation are permitted to be used
- The size must be based on the 60°C or 75°C ampacity
110.14 Electrical Connections

Pressure terminal or pressure splicing connectors and soldering lugs shall be identified for the material of the conductor.

Conductors of dissimilar metals shall not be in physical contact unless the device is identified for the purpose and conditions of use.

Connections are to ensure thoroughly good connection without damaging conductor.

Terminals not marked CO/ALR, copper or coppor clad only.

Screwless terminals for copper and CU clad solid or stranded

One wire per terminal unless marked otherwise

110.14(B) Conductor Splices

Twist-on Wire Connectors (typical)

Conductors are required to be spliced with devices suitable for the type of conductor material. Conductors of dissimilar metals are not to be intermixed unless the splicing device is identified for the purpose
### 110.14(B) Direct Burial Splices

- **Heavy-wall Heat Shrink Tubing**
- **Insulating-Resin Type**
- **Splice kit for Type UF Cable**

Wire connectors or splicing means installed on conductors for direct burial must be listed for such use. Conductor insulation must be suitable for direct burial.

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**Derating for Ambient Temperature**

- Where Type NM cable is installed in an ambient temperature of 108°F, an ampacity correction of .87 or 87% must be applied.

- If the cable being installed is 12 AWG copper, the ampacity is derated as follows:
  
  - 12 AWG copper from Table 310.15(B)(16) in 90º column is 30 amperes
  - Ampacity to be derated to 87%
  - 30 amperes x .87 = 26.1 amperes
  - Comply with 240.4(D): 12 AWG (max 20 amperes)
Table 310.15(B)(3)(a) Adjustment Factors for More Than Three Current-Carrying Conductors in a Raceway or Cable

<table>
<thead>
<tr>
<th>Number of Conductors</th>
<th>Percentage of Current Values in Ampacity Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 through 6</td>
<td>80</td>
</tr>
<tr>
<td>7 through 9</td>
<td>70</td>
</tr>
<tr>
<td>10 through 20</td>
<td>50</td>
</tr>
<tr>
<td>21 through 30</td>
<td>45</td>
</tr>
<tr>
<td>31 through 40</td>
<td>40</td>
</tr>
<tr>
<td>41 and above</td>
<td>35</td>
</tr>
</tbody>
</table>
310.15(A)(2) Exception - Ampacity Selection

Where two different ampacities apply to a circuit, the higher ampacity is permitted to be used beyond the point of transition, a distance equal to 3.0 m (10 ft) or 10 percent of the circuit length figured at the higher ampacity, whichever is less.

Note: Derating required where more than two cables with two or more current-carrying conductors are installed in top plate sealing foam, etc.

Situation 1 (Example):
Total length of cables = 45 m (150 ft); Cables not stacked or bundled, 3.0 m (10 ft) or less (Derating not required)

Situation 2 (Example):
Total length of cables = 15 m (50 ft); Cables not stacked or bundled, 1.5 m (5 ft) or less (10% of total length of cables) (Derating not required)

Derating for Number of Conductors

- Six 10/2 WG Type NM cables are bundled or stacked more than 600 mm (24 in.) without maintaining spacing
- Ampacity adjustment is applied as follows:
  - 10 AWG copper from Table 310.15(B)(16) in 90° column is 40 amperes
  - Twelve current-carrying conductors require a 50% derating factor
  - 40 amperes x .50 = 20 amperes
  - Maximum overcurrent protection of 20 amperes for other than motor loads
Article 100: Definitions

- **Branch Circuit**: “The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).”
- **Branch Circuit, Appliance**: “A branch circuit that supplies energy to one or more outlets to which appliances are to be connected, and that has no permanently connected luminaires that are not part of an appliance.”
- **Branch Circuit, General Purpose**: “A branch circuit that supplies two or more receptacles or outlets for lighting and appliances.”
- **Branch Circuit, Individual**: “A branch circuit that supplies only one utilization equipment.”
Article 100: Definitions

• **Branch Circuit, Multiwire:** “A branch circuit that consists of two or more ungrounded conductors that have a voltage between them, and a grounded conductor that has equal voltage between it and each ungrounded conductor of the circuit and that is connected to the neutral or grounded conductor of the system.”

• **Clothes Closet:** “A non-habitable room or space intended primarily for storage of garments and apparel.”

• **Cooking unit, Counter-Mounted:** “A cooking appliance designed for mounting in or on a counter and consisting of one or more heating elements, internal wiring, and built-in or separately mountable controls.”

• **Continuous Load:** “A load where the maximum current is expected to continue for 3 hours or more.”
Article 100: Definitions

- **Dwelling Unit:** “A single unit, providing complete and independent living facilities for one or more persons, including permanent provisions for living, sleeping, cooking, and sanitation.”

- **One-Family Dwelling:** “A building that consists solely of one dwelling unit.”

- **Two-Family Dwelling:** “A building that consists solely of two dwelling units.”

- **Three-Family Dwelling:** “A building that consists solely of three or more dwelling units.”

- **Feeder:** “All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device.”
Feeder or Service Load Calculations

- Article 230 makes reference to Article 220 for calculations.
- The calculated load for a feeder or service shall be not less than the sum of the loads on the branch circuits supplied as determined by Part II of Article 220, after any applicable demand factors permitted by Parts III or IV or required by Part V have been applied [220.40].
- Two load calculation methods provided for in Article 220:
  - Standard calculations in Part III of Article 220
  - Optional calculations in Part IV of Article 220
- Ampacity of service-entrance conductors from 310.15
- Minimum size is 100 amperes for service-entrance equipment and conductors [230.79(C), 230.42(B)].

Calculating Service-Entrance Conductor Sizes

<table>
<thead>
<tr>
<th>Service or Feeder Rating (Amperes)</th>
<th>Conductor (AWG or kcmil)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Copper</td>
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<tr>
<td>100</td>
<td>4</td>
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<tr>
<td>110</td>
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<tr>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>400</td>
<td>400</td>
</tr>
</tbody>
</table>

( Discussed in greater detail in Chapter 3 )
**220.12, Table 220.12, 210.11(A)**

**General Purpose Lighting**

\[
\frac{\text{Floor Area} \times 3 \text{ VA}}{120 \text{ Volts}} = \text{Amps, General Purpose Lighting}
\]

\[
\frac{\text{Amps, Gen. Purpose Lighting}}{15 \text{ or } 20 \text{ Amp Circuits}} = \text{Number of Circuits}
\]

\[
\frac{2100 \text{ sq. ft.} \times 3 \text{ VA}}{120 \text{ Volts}} = 52.5 \text{ Amps}
\]

\[
\frac{52.5 \text{ Amps}}{15 \text{ or } 20 \text{ Amp Circuits}} = 4 \text{ - } 15 \text{ or } 3 \text{ - } 20 \text{ Amp Circuits}
\]

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**Common Calculation Requirements**

- Ampacity of service-entrance conductors and “main power feeders” from Table 310.15(B)(7) permitted to be used through 400 amperes
- Nominal voltage of 120, 120/240, 240 and 120/208 used for various calculations
- Calculation of amperes rounded up where 0.5 or more
- Unit load for general purpose branch circuits is 3 VA per square foot from outside dimensions; this includes general use receptacles [220.12]
Common Calculation Requirements

• Two 20-ampere small-appliance branch circuits required (1500 VA each) - permitted in general lighting load demand factors (standard calculations) [220.52(A)]

• One laundry branch circuit required (1500 VA each) - permitted in general lighting load demand factors (standard calculations) [220.52(B)]

Rules for Standard Load Calculations

• General lighting load of 3 VA per square foot [220.12]
• Load of 1500 VA for each of the (2) small-appliance branch circuits required [220.52(A)]
• Load of 1500 VA for each laundry circuit [220.52(B)]
• Application of demand factors permitted [220.42]
• Other loads - ampere rating of appliance or load served
• Motor loads [430.22 (single motor) or 430.24 (motors and other loads)]
• Air-conditioning or refrigeration equipment [Article 440]
Rules for Standard Load Calculations

• Fixed electric space heating - 100 percent unless local demand factor

• Four or more appliances - 75 percent demand factor [220.53]

• Electric clothes dryers [220.54]

• Electric ranges [220.55]

• Noncoincident loads - permitted to omit smaller dissimilar load [220.60]

Application of Demand Factors

• Section 220.42 provides for application of a demand factor to the following loads:
  - General lighting load
  - Small-appliance branch circuits
  - Laundry branch circuit

First 3000 volt-amperes...............100 percent
From 3001 to 120,000 VA............35 percent
Remainder over 120,000 VA.........25 percent
Minimum Size of Grounded (Neutral) Conductor

- Calculate neutral load according to Section 220.61
- Neutral carries unbalanced load from ungrounded (hot) conductors
- Permitted to apply demand factors same as ungrounded conductors
- Range and dryers - 70 percent of load in accordance with Table 220.55 (ranges) and Table 220.54 (dryers)
- Additional 70 percent demand for load in excess of 200 amperes

Rules for Optional Load Calculations

- Dwelling must be served by a single 3-wire service or feeder [220.82(A)]
- Voltage must be 120/240 (single-phase) or 208 Y/120 3-wire [220.82(A)]
- Service or feeder must have an ampacity of 100 amperes or greater [220.82(A)]
- Nameplate rating known for all appliances that are fastened in place, on specific circuit, cooking appliances, etc. [220.82(B)(3)]
Rules for Optional Load Calculations

• Nameplate rating known of all motors, low power factor loads, heating and air-conditioning equipment [220.82(B)]

• Permitted to use the methods in 220.61 for calculating the load on the service or feeder neutral

Rules for Optional Load Calculations

• Loads identified as “general loads” and “remainder of the following loads” shall include the following [220.82(B)]:
  - Load of 1500 VA (each) - Two small-appliance branch circuits [210.11(C)(1)]
  - Load of 1500 VA for laundry branch circuit [210.11(C)(2)]
  - General lighting unit load of 3 VA per square foot [220.12]
  - Nameplate ampere or kVA rating of all motors and of all low power-factor loads
Rules for Optional Load Calculations

- Nameplate rating of all appliances that are fastened in place, permanently connected, or located to be on a specific circuit, ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers and water heaters [220.82(B)]

- Nameplate ampere or kVA rating of all motors and of all low-power factor loads [220.82(B)]

- These loads are subject to application of demand factor of the first 10 kVA at 100 percent and remainder at 40 percent [220.82(B)]
Article 100: Definitions

• **Service**: “The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.”

• **Service Cable**: “Service conductors made up in the form of a cable.”

• **Service Conductors**: “The conductors from the service point to the service disconnecting means.”

• **Service Conductors, Overhead**: “The overhead conductors between the service point and the first point of connection to the service-entrance conductors at the building or other structure.”

• **Service Conductors, Underground**: “The underground conductors between the service point and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure, inside or outside the building wall.”
  - **Informational Note**: Where there is no terminal box, meter, or other enclosure, the point of connection is considered to be the point of entrance of the service conductors into the building.
Article 100: Definitions

- **Service Drop**: “The overhead conductors between the utility electric supply system and the service point.”

- **Service-Entrance Conductors, Overhead System**: “The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop or overhead service conductors.”

- **Service-Entrance Conductors, Underground System**: “The service conductors between the terminals of the service equipment and the point of connection to the service lateral or underground service conductors.”

  - **Informational Note**: Where service equipment is located outside the building walls, there may be no service-entrance conductors or they may be entirely outside the building.

- **Service Equipment**: “The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the load end of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply.”
Article 100: Definitions

- **Service Lateral**: “The underground conductors between the utility electric supply system and the service point.”

- **Service Point**: “The point of connection between the facilities of the serving utility and the premises wiring.”
  - **Informational Note**: The service point can be described as the point of demarcation between where the serving utility ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the conditions of service.

230.24(A) Clearances Above Roofs

- Max. 300V
- Minimum 900 mm (3 ft)
- 900 mm (3 ft)
- Minimum 2.5 m (8 ft)
- Vertical clearances above roofs required
230.43 Raceways Permitted for Service Entrance

- Rigid metal conduit (RMC)
- Intermediate metal conduit (IMC)
- Rigid polyvinyl chloride conduit (PVC)
- Electrical metallic tubing (EMT)
- Electrical nonmetallic tubing (ENT)
- Flexible metal conduit (FMC)
- Liquidtight flexible metal conduit (LFMC)
- Liquidtight flexible nonmetallic conduit (LFNMC)
- High density polyethylene conduit (HDPE)
- Nonmetallic underground conduit with conductors (NUCC)
- Reinforced thermosetting resin conduit (RTRC)
230.66 Marking of Service Disconnecting Means

- Suitable for use as Service Equipment
- Suitable only for use as Service Equipment
- Suitable for use as Service Equipment - when not more than six mains are installed
- All service equipment shall be listed
- Also see 230.70(B)

Working Space – Space About Electrical Equipment

- Ample working space is required in the vicinity of service equipment so any repairs, operation, or servicing of equipment can be performed safely
- Minimum 750 mm (30 in.) wide in front or the width of the equipment whichever is greater
- Minimum headroom required – 2.0 m (6½ ft)
- Doors to swing a minimum of 90° angle
- Dedicated electrical space required above and below the electrical equipment
Chapter Four

Service Grounding and Bonding Requirements

Purpose of Grounding

- **Limit voltages** due to lightning, line surges, or unintentional contact with higher voltage lines. Proper grounding also serves to **stabilize the voltage** to ground during normal operation [250.4(A)(1)]

- Conductive materials enclosing electrical conductors or equipment shall be connected to earth so as to **limit the voltage** to ground on these materials [250.4(A)(2)]

- Conductive materials are grounded to **limit the voltage** to ground on these materials
Purpose of Bonding

- **Electrically conductive** materials such as metal water piping, metal gas piping, and structural steel members shall be bonded to the supply system grounded conductor or, in case of an ungrounded electrical system, to the electrical system grounded equipment, in a manner which establishes an effective path for fault current [250.4(A)(3) and (4)]

- Effective fault current path shall be continuous, capable of carrying the maximum fault current likely to be imposed on it, and shall have low impedance to facilitate overcurrent device operation [250.4(A)(5)]

250.50 Grounding Electrode System

- These grounding electrodes are required to be used where present. If any of these electrodes are inherent to the building or structure, they shall be used in the grounding electrode system:
  - 250.52(A)(1) Metal underground water pipe
  - 250.52(A)(2) Metal frame of a building or structure
  - 250.52(A)(3) Concrete-encased electrode
  - 250.52(A)(4) Ground ring
  - 250.52(A)(5) Rod and pipe electrode
  - 250.52(A)(6) Other listed electrodes
  - 250.52(A)(7) Plate electrodes
  - 250.52(A)(8) Other local metal underground systems or structures
250.53(D)(2) Supplemental Electrode Required

Metal underground water pipe is required to be supplemented by an additional electrode of the type specified in 250.52(A)(2) through (A)(8)

Supplemental grounding electrode shall be bonded to one of the following:

- Grounding electrode conductor
- Grounded service-entrance conductor
- Nonflexible grounded service raceway
- Any grounded service enclosure
- As provided by 250.32(B)

Connection within first 1.52 m (5 ft)

If the supplemental grounding electrode is a single rod, pipe, or plate, must be supplemented as well or must meet 25-ohm rule [250.53(A)(2) and Exception]

250.53(A)(2) Supplemental Electrode Required

A single rod, pipe or plate electrode required to be supplemented by an additional electrode as specified in 250.52(A)(2) through (A)(8)

No resistance measurement required for rod, pipe, and plate electrodes after these electrodes have been supplemented

Minimum 6 feet apart or follow manufacturer's instructions
250.32(B) Grounding at Separate Buildings

Building 1
- Grounded conductor

Building 2
- Grounded conductor

EGC in accordance with 250.118

250.32(B)
- Grounding at separate building or structure requires the use of an equipment grounding conductor

250.32(B) Exception
- Grounding at separate building or structure using the grounded circuit conductor permitted by exception only as follows:
  - Existing installations only
  - No EGC with feeder
  - No continuous metallic paths
  - No supply-side GFPE

Chapter Five

Cabinets and Meter Socket Enclosures
Article 100: Definitions

- **Cabinet:** “An enclosure that is designed for either surface or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.”

- **Panelboard:** “A single panel or group of panel units designed for assembly in the form of a single panel, including buses and automatic overcurrent devices, and equipped with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall, partition, or other support; and accessible only from the front.”
312.8 Enclosures for Overcurrent Devices

The wiring space of enclosures for switches or overcurrent devices is permitted to contain feed-through, splices, or tapped conductors where all of the following conditions are met:

- Conductors cannot fill wiring space to more than 40%.
- Where splices or taps are made, they cannot take up more than 75% at any cross section.
- Warning label applied to enclosure that identifies the closest disconnecting means for any feed-through conductors.

Chapter Six

Feeders and Overcurrent Protection
Sizing Feeder Conductors

• Sized to have an ampacity not less than required to supply the loads as calculated in Parts III, IV & V of Article 220 [215.2(A)(1)]

• Feeder conductors for a dwelling unit or mobile home need not be larger than the service-entrance conductors

• Ampacity values given in Table 310.15(B)(7) shall be permitted to be used for the “main power feeder”

• Ampacity values for feeders other than the “main power feeder” are derived from Table 310.16

310.15(B)(6) Main Power Feeder

• Table 310.15(B)(7) applies to a feeder conductor that serve as the “main power feeder” at each dwelling unit and are installed in raceway or cable with or without an equipment grounding conductor

• For application of this section, the main power feeder shall be the feeder between the main disconnect and the panelboard that supplies, either by branch circuits or by feeders, or both, all loads that are part or associated with the dwelling unit
310.15(B)(7) Main Power Feeder

Table 310.15(B)(7) - 120/240-Volt, 3-Wire, Single-Phase Dwelling Services and Feeders

The main power feeder supplies **all** branch circuits, feeders, or both, associated with the dwelling unit loads.

338.10(B) Type SE Cable Permitted as Feeders

Where Type SE cable is used for interior wiring, must generally follow installation rules of Type NM Cable (excluding ampacity ratings of 334.80)

Protect with 1.6 mm (1/16 in.) steel plate or equal where within 32 mm (1 1/4 in.) of surface (plate can be of lesser depth if listed for same)

No protection required where hole is more than 32 mm (1 1/4 in.) from surface

Range circuit rough-in

Dryer circuit rough-in

Type SE cable used for interior wiring

Sub-panelboard
Chapter Seven

Personnel Protection

Article 100: Definitions

- **Ground-Fault Circuit Interrupter (GFCI).** “A device intended for the protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device.”

- **Informational Note:** Class A ground-fault circuit interrupters trip when the current to ground is 6 mA or higher and do not trip when the current to ground is less than 4 mA.

- For further information, see UL 943, *Standard for Ground-Fault Circuit Interrupters*
Article 100: Definitions

• Arc-Fault Circuit Interrupter (AFCI). “A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.”

210.8 Location of GFCI

- All GFCIs for personnel must be installed in a readily accessible location
- This applies to 210.8(A), (B), and (C)

210.8(A)(7) GFCI - Dwelling Unit Sinks

GFCI is now required for all 125-volt, single-phase, 15- and 20-ampere receptacles installed within 1.8 m (6 ft) of the outside edge of a dwelling unit sink (not just laundry, utility or wet bar sinks)

GFCI requirements for kitchen sinks still covered by 210.8(A)(6)
3401.1
1. Section 210.8(A)(2) shall be modified to read:
Garages, and also accessory buildings that have a floor located at or below
grade level not intended as habitable rooms and limited to storage areas, work
areas, and areas of similar use except for the receptacle located to serve a
garage door opener when the device is a single receptacle and located in the
ceiling.

2. Section 210.8(A)(5) shall be modified to read:
Unfinished basements - for the purposes of this section, unfinished
basements are defined as portions or areas of the basement not intended as
habitable rooms and limited to storage areas, work areas, and the like.

Exceptions:
1. A receptacle supplying only a permanently installed fire alarm or burglar
alarm system shall not required to have ground-fault circuit-interrupter
protection.

2. A single receptacle located to serve a sump pump shall not be required
to have ground-fault circuit-interrupter protection when there is a duplex
receptacle with ground-fault circuit-interrupter protection within six (6) feet of
the sump pump.
Definitions

• Arc-Fault Circuit Interrupter (AFCI). “A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.”

210.12 Arc-Fault Circuit-Interrupters

• AFCI is a device intended to provide protection from the effects of arcing type faults
• AFCI recognizes the characteristics that are unique to arcing
• The entire branch circuit is required to be protected
• Required for all 125-volt, single-phase, 15- and 20-ampere branch circuits supplying outlets installed in dwelling unit in the following locations:
  - family rooms
  - dining rooms
  - living rooms
  - parlors
  - libraries
  - dens
  - bedrooms
  - sun rooms
  - recreation rooms
  - closets
  - hallways
  - similar rooms or areas
210.12(A) AFCI Protection

All 120 volt, single phase, 15- and 20-ampere branch circuits supplying outlets installed in dwelling unit bedrooms and other areas of the dwelling are required to be protected by a listed combination arc-fault circuit interrupter device.

AFCI protection required to be of the combination type
Combination type AFCI detects both parallel and series arc faults
Parallel Arc Fault = Direct contact of two opposite polarities
Series Arc Fault = An arc across a break in a conductor

210.12(A) Ex. No. 1 AFCI Device at First Outlet

Device-type AFCI protection is permitted at first outlet where the branch circuit is installed using RMC, IMC, EMT, Type MC, or steel armored Type AC cable meeting the requirements in 250.118
Combination-type listed AFCI device is required to be installed at the first outlet to provide protection for the remaining portion of the branch circuit.
210.12(B) and 406.4(D)(4)
Arc-Fault Circuit-Interrupter Protection

Listed Outlet Branch Circuit Type AFCI Device

Courtesy of Pass & Seymour/Legrand

210.12(A) Ex. No. 2 AFCI Device at First Outlet

Main rule at 210.12(A) requires AFCI combination-type protection installed to provide protection of the entire branch circuit.

Branch-circuit panelboard

AFCI outlet device installed at first outlet

Rigid metal conduit

Listed nonmetallic conduit encased in at least 50 mm (2 in.) of concrete

Ex. No. 2: Where a listed metal or nonmetallic conduit or tubing is encased in not less than 50 mm (2 in.) of concrete (between panelboard and first outlet), an outlet branch-circuit AFCI is permitted at the first outlet to provide AFCI protection for the remaining portion of the branch circuit.
210.12(B) AFCI for Extensions or Modifications

- Where a receptacle outlet is supplied by a branch circuit that requires AFCI protection as specified elsewhere in the NEC, a replacement receptacle at this replacement outlet shall be one of the following:
  - (1) A listed outlet branch circuit type AFCI receptacle
  - (2) A receptacle protected by a listed outlet branch circuit AFCI type receptacle
  - (3) A receptacle protected by a listed combination type AFCI type circuit breaker

- This requirement becomes effective January 1, 2014
- See NEC 406.4(D)(4)
406.12 Tamper-Resistant Receptacles

- All 125-volt, 15- and 20-ampere receptacles in areas of a dwelling unit referred to in 210.52 are required to be listed tamper-resistant receptacles.

- Receptacles in the following locations shall not be required to be tamper-resistant:
  - Receptacles located more than 1.7 m (5½ ft) above the floor
  - Receptacles part of a luminaire or appliance
  - Single or duplex receptacle for appliances located within dedicated appliance space (not easily moved)
  - Nongrounding receptacles used for replacements
Replacements With TR or WR Receptacles

- Listed tamper-resistant receptacles shall be provided where replacements are made at receptacle outlets that are required to be tamper-resistant elsewhere in the NEC [NEC 406.4(D)(5)]

- Weather-resistant receptacles shall be provided where replacements are made at receptacle outlets that are required to be weather-resistant elsewhere in the NEC [NEC 406.4(D)(6)]
210.52(A) Dwelling Unit Receptacle Outlets

- Spacing rules call for installation of receptacle outlets so that no point along the floor line in any wall space is more than 1.8 m (6 ft) measured horizontally from an outlet in that space.
- Includes 600 mm (2 ft) wall space and wall space occupied by fixed panels in exterior or interior walls.
- Does not include sliding panels in exterior or interior walls.
- Fixed room dividers are included in the 1.8 m (6 ft) measurement.

210.52(A) Receptacle Locations and Spacing
Figure 210.52(C)(1) Kitchen Countertop Receptacles

Where receptacle outlets are required to be provided

- Outlet within 600 mm (24 in.)
- Outlets not required if $X < 300$ mm (12 in.)
- Outlet within 600 mm (24 in.)

Sink or range extending from face of counter

---

Figure 210.52(C)(1) Kitchen Countertop Receptacles

Where receptacle outlets are required to be provided

- Outlets not required if $X < 450$ mm (18 in.)
- Outlet within 24 in.
- Outlet within 24 in.

Sink or range mounted in corner
210.52(E)(3) Balconies, Decks, and Porches

At least one receptacle outlet shall be installed within the perimeter of all balconies, decks, and porches (accessible from inside the dwelling unit)

Receptacle shall not be located more than 2.0 m (6½ ft) above the balcony, deck, or porch surface

210.52(I) Foyers

Foyers that are not part of a hallway having an area that is greater than 5.6 m² (60 ft²) are required to have a receptacle(s) located in each wall space 900 mm (3 ft) or more in width
300.4(A) Cable Protection Requirements

Type NM Cable

Steel plate 1.6 mm (1/16 in.)
(unless plate is listed for a thinner dimension)

Less than 32 mm (1 ¼ in.)

Protect if less than 32 mm (1 ¼ in.)

Where run through or parallel with framing members or furring strips protect wiring against physical damage

334.80 Ampacity of Type NM Cable

Draft- or fire-stopping materials

Wood framing

Note:
310.15(A)(2)
Exception is not applicable

Ampacity adjustment factors in Table 310.15(B)(3)(a) apply to the following:

1. Where more than two cables with two or more current-carrying conductors pass through wood framing without maintaining spacing and the wood framing is sealed with thermal insulation, sealing foam, or caulking material

2. Where more than two cables with two or more current-carrying conductors are installed in thermal insulation without maintaining spacing between the cables
Chapter Nine

Outlet, Device, Pull and Junction Boxes, Conduit Bodies and Fittings
### 314.27(A)(1) Boxes for Luminaires

Boxes at **wall-mounted** luminaire or lampholder outlets:
- Must be specifically designed for purpose
- Marked on the interior of the box to indicate the maximum weight of the luminaire permitted to be supported [if other than 23 kg (50 lb)]

Other boxes acceptable for supporting wall-mounted luminaire or lampholder if:
- Luminaire/lampholder weighs 3 kg (6 lb) or less
- Luminaire/lampholder or securing yoke is secured by not less than two No. 6 or larger screws

### 314.27(A)(2) Boxes for Luminaires

Boxes at **ceiling-mounted** luminaire or lampholder outlets:
- Must be specifically designed for the purpose so that a luminaire or lampholder may be attached
- Required to support luminaire weighing minimum 23 kg (50 lb)
- Luminaire weighing more than 23 kg (50 lb) must be supported independently of the outlet box (unless box is listed and marked for the maximum weight to be supported)
314.27(C) Boxes at Ceiling Fan Locations

At single or multi-family dwellings, spare, separately switched, ungrounded conductors at ceiling-mounted outlet boxes (in a location acceptable for a ceiling fan) require outlet box or system listed for sole support of a ceiling-suspended (paddle) fan.
410.16 Luminaire Clearances in Clothes Closets

Surface incandescent, LED, or fluorescent
Surface incandescent or LED
Recessed incandescent, LED, or fluorescent
Surface fluorescent only

150 mm (6 in.) for fluorescent luminaires
300 mm (12 in.) for incandescent or LED luminaires

Storage area shelf width
Minimum 300 mm (12 in.)

Storage area
1.8 m (6 ft) or highest rod
Minimum 600 mm (24 in.) wide

Surface-mounted fluorescent or LED luminaires permitted to be installed within the storage space where identified for this use

---

410.16(C) Incandescent or LED Luminaires

150 mm (6 in.)

Recessed incandescent or LED with completely enclosed lamp

Storage space

Surface-mounted incandescent or LED with completely enclosed lamp

300 mm (12 in.)

1.8 m (6 ft)

600 mm (24 in.)
410.16(C) Fluorescent Luminaires

150 mm (6 in.)

Surface-mounted fluorescent

Storage space

Recessed fluorescent

1.8 m (6 ft)

600 mm (24 in.)

150 mm (6 in.)

Surface-mounted fluorescent or LED luminaires shall be permitted to be installed within the storage space where identified for this use.

406.12 Tamper-Resistant Receptacles

Tamper-resistant receptacles not required for receptacles:
- located more than 1.7 m (5½ ft) above floor
- that are part of a luminaire or appliance
- located within dedicated space for appliances
- replacement nongrounding type

In all areas specified in 210.52, all nonlocking type 125-volt, 15- and 20-ampere receptacles required to be listed tamper-resistant receptacles.
406.4(D)(5) Receptacle Replacement
Tamper-Resistant Receptacles

Listed tamper-resistant receptacles are required for replacement receptacle outlets where a receptacle outlet is required to be tamper-resistant elsewhere in the Code.

See 406.12, 406.13, and 406.14 for tamper-resistant receptacle requirements.

406.4(D)(6) Receptacle Replacement
Weather-Resistant Receptacles

Listed weather-resistant receptacles are required for replacement receptacle outlets where a receptacle outlet is required to be weather-resistant elsewhere in the Code.

See 406.9(A) and 406.9(B) for weather-resistant receptacle requirements.
406.9 Receptacles in Damp or Wet Locations

In all wet locations, the cover must be weatherproof with or without an attachment plug inserted into the receptacle.

Permitted in damp locations only where receptacle is covered (attachment plug not inserted) and receptacle flap covers are closed while not in use.

All 15- and 20-ampere, 125- and 250-volt nonlocking type receptacles installed in damp and wet locations shall be listed weather-resistant type receptacles.

Chapter Eleven

Requirements for Appliances
422.12 Individual Branch Circuit Required

Central Heating Equipment

Individual branch circuit required

Auxiliary equipment directly associated with heating equipment such as electrostatic air cleaner permitted on heater individual branch circuit

Permanently connected air-conditioning equipment permitted on same heater individual branch circuit

Disconnecting means within sight of controller if motor is more than 1/6 horsepower

[NEC 422.31(C)]

422.16(A) Use of Flexible Cords Limited

Cord-and-Plug Connection Not Permitted

Cord-and-plug connection prohibited unless fastening means and mechanical connections are specifically designed to permit ready removal for maintenance or repair, and the appliance is intended or identified for flexible cord connection
422.16(B) Flexible Cords Permitted

Specific appliance receptacles required to be accessible
Flexible cords "identified for the purpose" (typical)

422.16(B)(4) Cord-and-Plug Connected Range Hood

Range hoods permitted to be cord-and-plug connected where identified on installation instructions by manufacturer and meets the following:

- Cord terminates in a grounding type plug
- Cord length is at least 450 mm (18 in.) and not more than 900 mm (36 in.)
- Receptacle located to avoid physical damage to the cord
- Receptacle is accessible
- Receptacle is supplied by an individual branch circuit
Chapter Thirteen

Air-Conditioning and Heat Pump Equipment

440.4(B) Minimum Circuit Ampacity

Branch circuit panelboard

Fusible type disconnect (when required by nameplate)

Branch circuit: 125% of rated-load current or minimum circuit ampacity from nameplate rating

Refer to nameplate for minimum circuit ampacity and maximum overcurrent protection
440.4(B) Nameplate Required

**Breezy Cool Air-Conditioning Equipment**

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<th>MFD 03/99</th>
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<td>Volts -</td>
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<td>Hertz 60</td>
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<td>Compressor RLA</td>
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<td>Total system charge</td>
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*HACR type breaker for USA

See instructions inside access panel

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**RHEEM AIR CONDITIONER**

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<tr>
<td>MIN. FUSE OR CKT. BRK. SIZE*</td>
<td>25/25 AMP</td>
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<td>TOTAL SYSTEM CHARGE</td>
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SEE INSTRUCTIONS INSIDE ACCESS PANEL

RHEEM AIR CONDITIONING DIVISION
FORT SMITH, ARKANSAS

HACR TYPE BREAKER FOR U.S.A.

92-20842-16-01
210.63 Service Receptacle Required

125-volt, single phase, 15- or 20-ampere receptacle outlet required within 7.5 m (25 ft) and on the same level as air-conditioning and refrigeration equipment.

(Receptacle required to be weather-resistant type if installed in damp or wet location)

110.26 Adequate Working Space Required

Working space required at disconnects and equipment.

(120/240 volt, single phase service-typical)

These working spaces permitted to overlap

750 mm (30 in.) wide x 900 mm (36 in.) deep working space at A/C disconnects and service equipment.
Chapter Fourteen

Swimming Pools and Similar Installations

Residential Code of Ohio

See BBS RCO Interpretation of Pools and its enforcement in the State of Ohio.
680.43 Ex. No. 2 Indoor Spas and Hot Tubs

A new Ex. No. 2 was added to 680.43 specifying that equipotential bonding requirements for listed self-contained spa or hot tub installed indoors above a finished floor is not required.

680.73 Hydromassage Bathtub - Accessibility

A receptacle for a cord- and plug-connected hydromassage bathtub, located under the tub and accessible only through an access opening, must be installed so that the receptacle face is within direct view from the access opening and located not more than 300 mm (1 ft) from the opening.
Outbuilding/ Accessory Building Not Defined in NEC

• These terms can be associated with any building that is detached from a one- or two-family dwelling and which serves a support or ancillary function to the dwelling

• This so-called “outbuilding” may include a garage, workshop, cabana, water pump house, boathouse, shed, or pool pump house
Article 225 - Outside Feeders and Branch Circuits

Separate buildings or structures permitted to be supplied by either overhead or underground wiring methods
Overhead clearances typical to those for service drops
Must comply with NEC Article 225 and 230

Minimum sizes for overhead conductors:
15 m (50 ft) or less - 10 AWG CU or 8 AWG AL
Greater than 15 m (50 ft) - 8 AWG CU or 6 AWG AL
(unless supported by a messenger wire)

Article 225 - Outside Feeders and Branch Circuits

Separate buildings or structures permitted to be supplied by either overhead or underground wiring methods

Underground burial depths and wiring methods:
* See NEC Table 300.5 for minimum burial depth requirements
Outbuilding Disconnecting Means

- Must comply with Part II of Article 225 [225.30 - 225.40]
- Installed at outbuilding outside or inside, nearest the point of entrance of feeder or branch-circuit conductors
- Disconnecting means required to be in readily accessible location
- Disconnecting means required to be grouped
- Maximum of six disconnecting means in each group
- Required to be suitable for use as service equipment
- For garages and outbuildings on residential property, a snap switch or set of 3-way or 4-way switches permitted
250.32(A) Grounding Electrode Required

- Separate buildings generally required to have a grounding electrode system as specified in 250.50
- Where no electrode is present at the building(s) or structure(s) served, one must be established and used
- Exception for buildings or structures supplied by a single branch circuit that includes an equipment grounding conductor
250.32(B) Methods for Grounding

- Outbuildings must comply with grounding requirements similar to that of the main structure
  - New installations - Feeder or branch circuit must provide a grounding means in the outbuilding and an equipment grounding conductor must be run with the supply conductors
  - Existing installations only - By exception, the grounded (neutral) conductor may be used for grounding purposes in certain limited cases for existing installations only

250.32(B)(1) EGC with Supply Conductors

Equipment grounding conductor required for grounding at second building for new construction

Feeder requires an EGC to the Building 2 and separation of the neutral conductors and EGCs at Building 2
Connect grounding electrode conductor(s) at Building 2 to feeder disconnect enclosure (equipment grounding terminal bar)
250.32(B)(1) Exception: Existing Installations Only

Use of grounded conductor for grounding at second building permitted for existing installations only

This method permitted for **existing premise wiring only** and where all of the following conditions are met:

1. An EGC is not run with the supply to the building or structure
2. There are no continuous metallic paths bonded to the grounding system in both buildings or structures involved
3. GFP of equipment has not been installed on the supply side of the feeder

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Chapter Sixteen

Existing Electrical Installations and Wiring
Knob-and-Tube Wiring

• Requirements located in Article 394 of the NEC
• Permitted only for extensions of existing circuits
• By special permission by the AHJ in:
  (1) hollow spaces of walls and ceilings, and
  (2) unfinished attic and roof spaces
• Not to be used where spaces are insulated by loose, rolled or foamed-in-place insulation that envelops conductors
• Maintain 75 mm (3 in.) clearance between conductors and 25 mm (1 in.) from surface or enclose in flexible nonmetallic tubing
• Splices soldered unless approved devices are used

Residential Code of Ohio
Electrical Requirements

Presented By:
Instructors of the Ohio Chapter
International Association of Electrical Inspectors

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