



# **ELECTRICAL REQUIREMENTS**

## **Specific Information for Electrical Work Installers**

This handout is intended to be a **general overview** of residential electrical requirements as noted in the **2017 National Electrical Code**. This handout is not all inclusive and may not be helpful to a homeowner who is unfamiliar with electrical terminology. Additional information and knowledge is needed to properly install electrical wiring that is essentially free from fire and electric shock hazard. For complete information and assistance, please refer to authoritative publications based on the **2017 National Electrical Code ©**

It is illegal for unlicensed homeowners to install electrical wiring in two-family dwellings, apartment buildings, condominium buildings, certain townhouse buildings, manufactured homes in parks, recreational vehicles in parks, floating buildings on public waterways, or in or on any property that is rented, leased, or occupied by others.

A rough-in inspection must be made before insulation, sheet-rock, paneling, or other materials cover any electrical wiring. Underground wiring must be inspected before the trench is back-filled. Where wiring is concealed before inspection, the person responsible for concealing the wiring shall be responsible for all costs resulting from uncovering and replacing the covering material.

Except for the final connection to switches, receptacles, and lighting fixtures, all ground wires and other wires in boxes must be spliced and pigtailed for the rough-in inspection.

The installer shall schedule a final inspection when the electrical work is completed prior to the wiring being utilized and the space occupied.

### **GENERAL ROUGH IN REQUIREMENTS**

Except for the final connection to switches, receptacles, and lighting fixtures, all ground wires and other wires in boxes must be spliced and pigtailed for the rough-in inspection.

**NEC 110.14(B) Splices.** Wires shall be spliced and joined with splicing devices (wire nuts) identified for the use.

**NEC 300.4 Cables and raceways where installed through bored holes in wood framing members.** Cables and raceways shall be protected from damage. Where installed through bored holes in wood framing members, the holes shall be bored so that the edge of the hole is not less than 1¼ inch from the nearest edge of the wood member. Where this distance cannot be maintained, the cable or raceway shall be protected from penetration by nails or screws by a steel plate, sleeve, or equivalent at least 1/16 inch thick.

**NOTE: Local building codes will help you determine where holes or notches may be safely made in joists.**

**NEC 300.4(D) Cables and raceways installed parallel to framing members and furring strips.** In both exposed and concealed locations, where a cable- or raceway-type wiring method is installed parallel to framing members, such as joists, rafters, or studs, or is installed parallel to furring strips, the cable or raceway shall be installed and supported so that the nearest outside surface of the cable or raceway is not less than 1¼ inch from the nearest edge of the framing member or furring strips where nails or screws are likely to penetrate. Where this distance cannot be maintained, the cable or raceway shall be protected from penetration by nails or screws by a steel plate, sleeve, or equivalent at least 1/16 inch thick.

**NEC 334.30 Securing NM (Romex) cable.** Type NM (nonmetallic) cables shall be secured every 4.5 feet and within 12 inches of all two or more opening nonmetallic boxes & 8 inches of all single opening nonmetallic boxes (**NEC 314.17(C) Exception**)

## **GENERAL ROUGH IN REQUIREMENTS: CONTINUED**

**NEC 314.17(B)&(C) The outer jacket of type NM cable** shall be secured to the box and extend into the box and beyond any cable clamp a minimum of ¼ inch.

**NEC 300.14 The minimum length of wires, including grounding wires, at all boxes** shall be a minimum of 6 inches and extend at least 3 inches beyond the front edge of the box.

**NEC 300.22(C) Plenum spaces (cold air returns)** Type NM cable shall not be installed in plenum spaces (cold air returns), but in dwelling units may be installed perpendicular through joist or stud spaces used as such.

**NEC 334.12 Types NM and NMS cables shall not be used under the following conditions or in the following locations:**

- (1) Where exposed to corrosive fumes or vapors.
- (2) Where embedded in masonry, concrete, adobe, fill, or plaster.
- (3) In a shallow chase in masonry, concrete, or adobe and covered with plaster, adobe, or similar finish
- (4) **In wet or damp locations** such as the interior of all raceways installed above grade as on the exterior of a structure or below grade underground.

**NEC 314.29 Junction boxes** shall be installed so that the wiring contained in them can be rendered accessible without removing any part of the building or structure.

**NEC 314.23 All electrical boxes** shall be rigidly secured to the building structure.

**NEC 314.27(C) Boxes used as the sole support for a ceiling-suspended paddle fan** shall be listed and not be used as sole support for fans weighing more than 70 lbs. Where spare conductors are installed to a location acceptable to a ceiling fan, a listed fan box shall be installed.

**NEC 110.12(A) Unused openings in boxes** shall be effectively closed. A non-metallic box shall be replaced if cable openings are punched but not used.

The Minnesota Energy Code requires that all penetrations through an air barrier be sealed. Sealing applies to all penetrations including the service entrance, conduit, cables, panels, recessed luminaires and electrical boxes.

**NEC 250.134 All electrical equipment, including raceways, metal boxes and equipment** shall be connected to an equipment grounding conductor with a 10-32 machine screw or other approved methods.

**NEC 404.2(C) The grounded (white) conductor for lighting circuit(s)** shall be provided at a minimum of one location where switches control that room lighting loads.

**NEC 200.7(C) Where permanently re-identified at each location where it is visible and accessible**, the conductor with white colored insulation in type NM (Romex) cable may be used as an ungrounded (hot) conductor. Examples: 240 volt Water heaters, 240 volt Air conditioners.

**NEC 300.3(B) All conductors of the same circuit**, including grounding and bonding conductors shall be contained in the same raceway, cable, or trench.

## GENERAL ROUGH IN REQUIREMENTS: CONTINUED

**NEC 314.16** The number of conductors and devices contained within electrical boxes determine the cubic inch size of box needed. Nonmetallic boxes are marked with their cubic inch capacity.

Cubic Inches Required for Boxes			
Conductor Size	14 AWG	12 AWG	10 AWG
Each insulated wire	2	2.25	2.5
All grounding wires combined	2	2.25	2.5
Each switch or receptacle	4	4.5	5
All internal cable clamps	2	2.25	2.5

Example: a box with four 14/2 w/ground type NM cables:

<b>8 insulated wires</b>	<b>= 16 cubic inches</b>
<b>All 4 grounding wires</b>	= 2 cubic inches
<b>1 switch</b>	= 4 cubic inches
<b>1 receptacle</b>	= 4 cubic inches
<b>All cable clamps</b>	= 2 cubic inches
<b>Minimum Box Volume</b>	<b>= 28 cubic inches</b>

**NEC 240.4** Conductors shall be protected in accordance with their ampacity per Table 310.15 and 240.4(A-G)

### NEC 310.15 Maximum Overcurrent Protection

	Minimum Wire Size	
	Copper	Aluminum
Fuse or Circuit Breaker Size		
15 amp	14	N/A
20 amp	12	N/A
30 amp	10	8
40 amp	8	6
50 amp	6	4

Note: Conductors that supply motors, air-conditioning units, and other equipment may have overcurrent protection that exceeds the above limitation

## Branch Circuits & Receptacle Outlets Required

**NEC 210.52(A)(1-4) Receptacle outlet spacing in habitable rooms.** Receptacles shall be installed such that no point measured horizontally along the floor line of any wall space is more than 6 feet from a receptacle outlet. A receptacle shall be installed in each wall space 2-feet or more in width.

**Definition of a Wall Space:** As used in this section, a wall space shall include the following:

- (1) Any space 2 feet or more in width (including space measured around corners) and unbroken along the floor line by doorways and similar openings, fireplaces, and fixed cabinets.
- (2) The space occupied by fixed panels in exterior walls, excluding sliding panels.
- (3) The space afforded by fixed room dividers, such as freestanding bar-type counters or railings

# **GENERAL ROUGH IN REQUIREMENTS: CONTINUED**

## **Branch circuits & Receptacle Outlets Required: Continued**

**NEC 210.11(C)(1)(2)(3)&(4) and 422.12 Required branch circuits.** In addition to the branch circuits installed to supply general illumination and receptacle outlets in dwelling units, the following minimum requirements apply:

- Two 20-amp circuits for the kitchen countertop receptacles  
(Note: will need to carefully examine all kitchen small appliances you are purchasing as to the total Amp/Watts requirements of each appliance. (Examples: microwave, coffee makers, espresso machines, dishwasher, disposal etc.) If **not fixed** in place shall not exceed 80% (16 amps or 1920 watts) of the 20 amp circuit. If **fixed** in place shall not exceed 50% (10 amps or 1200 watts) of the 20 amp circuit)
- One 20-amp circuit for the laundry receptacle(s)
- One 20-amp circuit for the bathroom receptacle(s)
- One 20-amp circuit for attached or detached garage receptacle(s)
- An individual branch circuit for central heating equipment (furnace)

**NEC 210.11(C)(1) Receptacles installed in the kitchen to serve countertop spaces** shall be supplied by not less than two separate 20 amp small appliance branch circuits.

**NEC 210.52(C) Countertops.** In kitchens, pantries, breakfast rooms, dining rooms, and similar areas of dwelling units, receptacle outlets for countertop spaces shall be installed in accordance with 210.52(C)(1) through (C)(4).

**(1) Wall Countertop Spaces.** A receptacle outlet shall be installed at each wall countertop space that is 12 inches or wider. Receptacle outlets shall be installed so that no point along the wall line is more than 24 inches measured horizontally from a receptacle outlet in that space. Countertop spaces separated by range tops, sinks or refrigerators are separate spaces.

**(2) Island Countertop Spaces.** At least one receptacle shall be installed at each island countertop space with a long dimension of 24 inches or greater and a short dimension of 12 inches or greater.

**(3) Peninsular Countertop Spaces.** At least one receptacle outlet shall be installed at each peninsular countertop space with a long dimension of 24 inches or greater and a short dimension of 12 inches or greater. A peninsular countertop is measured from the connecting edge.

**(4) Receptacle Outlet Location.** Receptacle outlets shall be located on or above, but not more than 20 inches above, the countertop (receptacle outlet assemblies listed for the application shall be permitted to be installed in countertops) and must not be located more than 12 inches below a countertop and cannot be located where the countertop overhang above the receptacle is greater than 6 inches. Receptacle outlets rendered not readily accessible by appliances fastened in place, appliance garages, sinks, range tops or appliances occupying dedicated space shall not be considered as these required outlets.

**NEC 210.11(C)(3) Bathroom Branch Circuits.** At least one 120-volt, 20-ampere branch circuit shall be provided to supply a bathroom receptacle outlet(s). Such circuits shall have no other outlets. *Exception: Where the 20-ampere circuit supplies a single bathroom, outlets for lights other equipment within the same bathroom shall be permitted to be supplied by this circuit, this circuit shall NOT extend beyond this single bathroom.*

**NEC 210.52(D) At least one receptacle outlet shall be installed in bathrooms.** This receptacle outlet shall be located on a wall or partition that is adjacent to the basin or basin countertop, located on the countertop, or installed on the side or face of the basin cabinet. In no case shall the receptacle be located more than 12 inches below the top of the basin. Receptacle outlet assemblies listed for the application shall be permitted to be installed in the countertop.

**NEC 210.52(H) Hallways of 10 feet or more in length** shall have at least one receptacle outlet. As used in this subsection, the hallway length shall be considered the length along the centerline of the hallway without passing through a doorway.

**NEC 210.52(I) All foyers** with an area of 60 sq. feet or greater shall have a receptacle(s) outlet located in each wall space of 3 feet or more in width. (Doorways, door-side windows that extend to the floor, and similar openings shall not be considered wall space)

# GENERAL ROUGH IN REQUIREMENTS: CONTINUED

## Branch circuits & Receptacle Outlets Required: Continued

### Outdoor Receptacle Requirements

**NEC 210.52(E)(1) Front and back receptacle location for a dwelling.** At least one 15 or 20 amp receptacle outlet accessible at grade level shall be installed at the front and back of a dwelling.

**NEC 210.52(E)(3) Balconies, decks and porches, regardless of size, that are accessible from inside a dwelling unit** shall have at least one receptacle outlet installed within the perimeter.

**NEC 210.63 Air-Conditioning and Heating equipment** a 125-volt 15 or 20 amp receptacle shall be installed at an accessible location for the servicing of air-conditioning and heating, equipment. The receptacle shall be located on the same level and within 25 feet of the air-conditioning and heating equipment.

**NEC 406.9(B)(1) & 406.4(D)(6) All new receptacles installed in damp or wet locations and existing receptacles in damp or wet locations** that are being replaced shall be:

1. GFCI protected.
2. Listed as **weather-resistant (WR) & tamper-resistant (TR)** type.
3. When installed in a wet location shall have an in-use weatherproof cover installed, the in-use cover shall be listed and identified as “**Extra Duty**”.

**NEC 210.52(G) Basements, Garages, and Accessory Buildings.** For a one-family dwelling, at least one receptacle outlet shall be installed in the areas specified in 210.52(G) (1) through (3). These receptacles shall be in addition to receptacles required for specific equipment.

**(1) Garages.** In each attached garage and in each detached garage with electric power you shall supply at least one 120-volt, 20-ampere branch circuit to supply receptacle outlets. This circuit shall have no lighting or other outlets. *Exception: This circuit shall be permitted to supply readily accessible outdoor receptacles.*

**Required Receptacles-** One receptacle for **each** vehicle bay installed 5½ feet or less above the floor.

**(2) Accessory Buildings.** In each accessory building with electric power.

**(3) Basements.** In each separate unfinished portion of a basement.

**Note:** *GFCI protection is required by 210.8(A)(5) for ALL receptacles in unfinished basements and by 210.8(A)(2) for ALL receptacles installed in garages & accessory buildings.*

**NEC 210.17 Electric Vehicle Branch Circuit.** An outlet(s) installed for the sole purpose of charging electric vehicles shall be supplied by a separate branch circuit. This circuit shall have no other outlets.

### Lighting Outlets Required

**NEC 210.70(A)(1) Habitable Rooms.** At least one wall switch–controlled lighting outlet shall be installed in every habitable room, bathroom, hallways, stairways where one or more lighting outlet(s) are installed for interior stairways, there shall be a wall switch at each floor level, and landing level that includes an entryway, to control the lighting outlet(s) where the stairway between floor levels has six risers or more.

**NEC 210.70(A)(2) Additional Locations.** At least one wall switch–controlled lighting outlet shall be installed in attached garages, detached garages with electric power. In addition in attached garages and detached garages at least one wall switch controlled lighting outlet shall be installed to provide illumination on the **exterior side** of service entrance doors or exits with grade level access. *Note: A vehicle door in a garage shall not be considered as a service entrance door.*

**NEC 210.70(A)(3) Storage or Equipment Spaces.** For attics, underfloor (crawl) spaces, utility rooms, and basements, at least one lighting outlet containing a switch or controlled by a wall switch shall be installed where these spaces are used for storage or contain equipment requiring servicing. At least one point of control shall be at the usual point of entry to these spaces. The lighting outlet shall be provided at or near the equipment requiring servicing.

## GENERAL REQUIREMENTS FOR FINAL

**NEC 404.10(B) & 406.5 Switches & Receptacle devices shall be secured to electrical boxes** with the provided machine screws or shall be machine screws having 32 threads per inch in accordance with the manufacturer's instructions. ***This means the use of drywall screws or any screw, other than a machine screw, is prohibited.***

**NEC 406.4(A) & NEC 200.11 Receptacle outlets** shall be of the grounding type, be grounded, and have proper polarity.

**NEC 110.14(A) Only one wire shall be installed under a terminal screw.** In boxes with more than one grounding wire, the grounding wires shall be tied together with splicing devices (wire nuts) with a 6 inch "pigtail" for attaching to the grounding terminal of the switch, receptacle or any other device.

**NEC 406.12 & 406.4(D)(5) All 125-volt and 250-volt, 15- and 20- amp receptacles installed or replaced** in dwelling units shall be listed ***tamper-resistant***. This includes receptacles installed outdoors, in basements and in garages. *Three exceptions to this requirement include receptacles located 5½ feet or more above the floor, a receptacle in space dedicated for an appliance that is not readily moved and receptacles that are part of a luminaire.*

**NEC 406.9(B)(1) & 406.4(D)(6) All new receptacles installed in damp or wet locations and existing receptacles in damp or wet locations** that are being replaced shall be:

1. GFCI protected.
2. Listed as ***weather-resistant (WR) & tamper-resistant (TR)*** type.
3. When installed in a wet location shall have an in-use weatherproof cover installed, the in-use cover shall be listed and identified as "**Extra Duty**".

**NEC 408.4(A) Every circuit and circuit modification** shall be legibly identified as to its clear, evident and specific purpose or use in sufficient detail on a directory located on the face or inside of the electrical panel doors.

## ARC-FAULT CIRCUIT INTERRUPTER (AFCI) REQUIREMENTS

**NEC 210.12(A)** All 120 volt, single-phase, 15 and 20 amp branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar rooms or areas shall be protected by a listed (AFCI) ***arc-fault circuit interrupter, combination type***, installed to provide protection of the entire branch circuit.

**NEC 210.12(B)** In any of the areas specified above where branch circuit wiring is ***modified, replaced, or extended***, the branch circuit shall be protected by a listed (AFCI) ***arc-fault circuit interrupter, combination type circuit breaker*** installed to provide protection of the entire branch circuit or a listed ***outlet branch-circuit type AFCI*** located at the first receptacle outlet of the existing branch circuit.

**NEC 406.4(D)(4)(1-3) Where an existing receptacle outlet is replaced** in an area of a house that is required elsewhere in this Code to be protected by AFCI (Arc-Fault Circuit Interrupter) it shall be AFCI protected by 1 of the 3 following methods.

1. An AFCI circuit breaker installed in the electric panel.
2. An AFCI receptacle.
3. A receptacle protected by being installed on the load side of method 1 or 2 above.

**The reset/test button for all AFCI protected circuits shall be installed in a "*Readily Accessible*" Location.**

**NEC Definition of "*Readily Accessible*"** " Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to take actions such as to use tools (other than keys), to climb over or under, to remove obstacles, or to resort to portable ladders, and so forth

## **GROUND-FAULT CIRCUIT-INTERRUPTER (GFCI) REQUIREMENTS**

**NEC 210.8(A)(1-10)** Ground-fault circuit-interrupter (GFCI) protection shall be provided for all 125-volt, 15 and 20 amp receptacle outlets installed in.

**(1) Bathrooms** including receptacles that are integral with luminaires. *There are no exceptions to the bathroom receptacle outlet GFCI requirement.*

**(2) 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. *All 125-V, single-phase, 15- and 20-A receptacles installed in garages must be GFCI protected. There are **NO** exceptions.*

**(3) Outdoors**

**(4) Crawl spaces** — at or below grade level

**(5) Unfinished basements** — for 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.

**(6) Kitchens** — where receptacles are installed to serve the countertop surfaces.

**(7) All sinks** — where receptacles are installed within 1.8 m (6 ft.) from the top inside edge of the bowl of the sink. When determining the need for GFCI protection of a receptacle in the vicinity of a sink the distance is to be measured as the shortest path a 6 ft. long appliance cord would follow from the top inside edge of the bowl of the sink to the receptacle, without piercing a floor, wall, ceiling, door, cabinet door or barrier.

**(8) Boathouses.**

**(9) Bathtubs or shower stalls** — where receptacles are installed within 1.8 m (6 ft.) of the outside edge of the bathtub or shower stall.

**(10) Laundry areas**

**NEC 210.8(D) GFCI protection shall be provided for all outlets that supply dishwashers.** *Dishwashers must be GFCI protected whether direct wired or cord connected into an outlet and whether 120 or 240 volt.*

**NEC 210.8(E) Crawl Space Lighting Outlets.** GFCI protection shall be provided for lighting outlets not exceeding 120 volts installed in crawl spaces.

**NEC 680.71 Hydromassage (whirlpool) bathtubs** and their associated electrical components shall be on an individual branch circuit(s) and protected by a readily accessible ground-fault circuit interrupter. *Note: often these units require 2 individual circuits, one for the pump and one for the in-line water heater.*

All 125-volt receptacles not exceeding 30 amperes installed within 6 feet of the inside walls of a hydromassage bathtub shall be GFCI protected.

**NEC 680.73 Hydromassage (whirlpool) bathtub electrical equipment** shall be accessible without damaging the building structure or building finish. Where the hydromassage bathtub is cord and plug connected with the supply receptacle accessible only through a service access opening, the receptacle shall be installed so that its face is within direct view and not more than 12 inches from the opening.

**NEC 680.21(C) All 15- and 20-amp, single-phase, 120 volt through 240-volt pool pump motors**, whether cord and plug connected or direct wired, shall be provided with GFCI protection.

**Note:** An equipotential bonding grid to mitigate step and touch voltage potential shall be installed at outdoor swimming pools, spas and hot tubs.

**The reset/test button for all GFCI protected circuits shall be installed in a “Readily Accessible” Location.**

**NEC Definition of “Readily Accessible”** Capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to take actions such as to use tools (other than keys), to climb over or under, to remove obstacles, or to resort to portable ladders, and so forth

## LUMINAIRES (Light Fixtures)

**NEC 410.6** All luminaires, lamp holders, and retrofit kits shall be listed.

**NEC 410.16(A)(C)** Only luminaires of the following types shall be permitted in a closet:

- (1) Surface-mounted totally enclosed incandescent or LED luminaires with a completely enclosed light source installed **on** the wall above the door or **on** the ceiling, if installed 12 inches or more from the nearest point of closet combustibles.
- (2) Surface-mounted or recessed fluorescent, recessed incandescent with a completely enclosed trim or recessed LED luminaires with a completely enclosed light source, if installed 6 inches or more from the nearest point of closet combustibles.
- (3) Surface-mounted fluorescent or LED luminaires identified as suitable for installation within the closet storage space.

**NEC 410.16(B)** Incandescent luminaires with open or partially enclosed lamps and pendant fixtures or lamp-holders are **not permitted** in clothes closets.

**NEC 410.2** Closet storage space is the area bounded by the sides and back closet walls extending from the closet floor to a height of 6-feet' or the highest clothes-hanging rod and then out 24-inches from the sides and back of the closet walls respectively, and then continuing from there to the ceiling at a distance of 12-inches or the shelf width, whichever is greater.

**NEC 410.10(A)** Luminaires installed in wet or damp locations shall be marked as "suitable for use in wet or damp locations", correspondingly.

## EQUIPMENT LISTING and LABELING

**Minnesota Rules 3800.3620** All electrical equipment, including luminaires, devices and appliances used as part of or in connection with an electrical installation shall be listed and labeled by a Nationally Recognized Testing Laboratory (NRTL) as having been tested and found suitable for a specific purpose.

**NEC 110.3(B)&(C)** All electrical equipment shall be listed, installed and used in accordance with the listing requirements and manufacturer's instructions.

## ELECTRICAL SERVICES CONDUCTOR SIZE

### **NEC 310.15(B)(7)(1-4)**

#### **CONDUCTOR SIZES FOR 120/240 VOLT 3-WIRE, SINGLE-PHASE, DWELLING SERVICES AND FEEDERS**

<b>Copper</b>	<b>Aluminum</b>	<b>Service Rating</b>
4 AWG	2AWG	100 amps
1AWG	2/0	150 amps
2/0	4/0	200 amps
400 kcmil	600 kcmil	400 amps

## OVERHEAD ELECTRICAL SERVICES

**NEC 230.9(A)(B)&(C)** Clearances of overhead Service Conductors. Service conductors shall have a clearance of not less than 3 feet from windows that are designed to be opened, doors, porches, balconies, ladders, stairs, fire escapes, or similar locations. *Exception: Conductors run above the top level of a window shall be permitted to be less than the 3 feet requirement.*

**NEC 230.24(B)** Vertical Clearance for Overhead Service Conductors. Overhead service conductors shall have the following minimum clearance from final grade:

- (1) 10 feet — at the electrical service entrance to buildings, also at the lowest point of the drip loop of the building electrical entrance, and above areas or sidewalks accessible only to pedestrians, measured from final grade or other accessible surface such as platforms, projections, decks, stair landings or surfaces from which they might be reached.
- (2) 12 feet — over residential property and driveways.

## **OVERHEAD ELECTRICAL SERVICES: CONTINUED**

**NEC 230.28 Service Masts used as Supports** must meet the requirements of both A & B below.

**(A) Strength.** The service mast shall be of adequate strength and extend a Maximum of 3 feet above the roof if more than 3 feet it shall be supported by braces or guy wires to withstand safely the strain imposed by the overhead service conductors. Hubs intended for use with a conduit that serves as a service mast shall be identified for use with service-entrance equipment.

**(B) Attachment.** Service-drop or overhead service conductors shall not be attached to a service mast between a weatherhead or the end of the conduit and a coupling, where the coupling is located above the last point of securement to the building or other structure or is located above the building or other structure.

**NEC 230.7 Other Conductors in Raceway or Cable** Conductors other than service conductors shall not be installed in the same service raceway or service cable.

## **ELECTRICAL SERVICE DISCONNECTS AND PANELBOARDS**

**NEC 230.70(A) The service disconnecting means** shall be installed at a readily accessible location either outside a building or structure or inside **nearest the point of entrance** of the service conductors.

**NEC 250.28 A main bonding jumper** or the green bonding screw provided by the panel manufacturer shall be installed in the Service Disconnect.

**NEC 230.70(B) The main breaker in the service panel** or disconnect shall be permanently marked as the “**Service Disconnect**”

**NEC 230.70(A)(1)&(2)** Service disconnecting means & all electrical panels shall be readily accessible and shall not be located in **bathrooms**.

**NEC 240.24(D)** Electrical panels shall not be located in the vicinity of easily ignitable materials such as **clothes closets**.

**NEC 408.36(D)** Plug-in type overcurrent devices that are back-fed shall be secured by an additional approved device if used as a service disconnect.

**NEC 110.26** Sufficient working space shall be provided around electrical equipment. The depth of that space in the direction of access to live parts shall be a minimum of 3-feet. The minimum width of that space in front of electrical equipment shall be the width of the equipment or 30 inches whichever is greater. This workspace shall be clear and extend from the floor to a height of 6 feet 6 inches. This space shall not be used for storage, countertops, cloths washing or drying appliances or any other equipment or obstructions that blocks access to this designated electrical space.

**NEC 210.4(B) Each multi-wire** (2 phase (hot) conductors and one neutral (white) conductors all in same cable) branch circuits shall be provided with a 2 pole breaker or listed handle ties that will simultaneously disconnect both ungrounded (hot) conductors.

**NEC 210.4(D) The ungrounded (hot) and grounded (neutral/white) circuit conductors** of each multi-wire branch circuit shall be grouped by cable ties or similar means in at least one location within the panelboard.

**NEC 408.4(A) Every circuit and circuit modification shall be legibly identified as to its clear, evident and specific** purpose or use in sufficient detail on a directory located on the face or inside of the electrical panel doors.

**NEC 110.26(D) Illumination** shall be provided for all working spaces about service equipment and panelboards.

**NEC 408.41 Each grounded (neutral/white) circuit conductor within a panelboard shall terminate in an individual terminal.**

**NEC 408.3(2) Service Panelboards must have barriers** placed in all service panelboards, such that no uninsulated, ungrounded service terminal is exposed to inadvertent contact by persons or maintenance equipment while servicing.

**NEC 110.14** Conductors of dissimilar metals shall not be intermixed unless the device is identified for the purpose. Listed anti-oxidant compound shall be used on all aluminum conductor terminations, unless the device manufacturer states that it is not required.

## SERVICE RACEWAYS

**NEC 300.7(A)** Portions of raceways or sleeves subject to different temperatures (i.e. passing from the interior to the exterior of a building) shall be sealed with an approved material to prevent condensation from entering equipment.

**NEC 230.54(G)** Service entrance raceways shall be rain tight and arranged to drain.

**NEC 300.9** The interior of raceways installed in wet locations above grade shall be considered wet locations and the wire type installed shall comply with **NEC 310.10(C)** (type NM (Romex) cannot be used in conduit attached to outside of a building)

**NEC 300.4(G)** Where raceways containing ungrounded conductors No. 4 or larger enter a cabinet, box, or enclosure; the conductors shall be protected by a bushing providing a smoothly rounded insulating surface.

## GROUNDING and BONDING

**NEC 250.50** All grounding electrodes that are present at each building or structure served shall be bonded together to form the grounding electrode system.

**NEC 250.52(A)(1) Electrodes include all metal underground water pipe** including abandoned well piping, a concrete encased electrode, ground rod, metal well casing.

**NEC 250.68(C) Connection of the grounding electrode conductor to the metal underground water pipe** must be within 5 feet of where the metal underground water pipe enters the building or structure.

**NEC 250.53(D)(2) A metal underground water pipe shall be supplemented** by an additional electrode, such as a concrete encased electrode, ground rod, well casing or underground well metal well piping.

**NEC 250.53(A)(2) If a ground rod is installed** as part of the grounding electrode system it shall be supplemented by an additional ground rod, spaced at least 6 feet apart. *Note: many rod manufactures require their rods to be driven twice the distance apart as length of the rod,*

**NEC 250.64(C) The grounding electrode conductor shall be continuous**, securely fastened and protected from physical damage.

**NEC 250.66 The size of the grounding electrode conductor** shall be determined by the size of the service-entrance conductors, per the chart:

**100 amp** Service - # \*8 copper or # 6 Aluminum (\*#8 if protected from physical damage)

**150 amp** Service - # 6 copper or # 4 Aluminum

**200 amp** Service - # 4 copper or # 2 Aluminum

**400 amp** Service - # 1/0 copper or # 3/0 Aluminum

**NEC 250.94 An intersystem bonding** termination with a **minimum of 3 open** conductor terminals for the bonding of other systems such as telephone, cable TV, satellite system, etc. must be provided at all new and updated electrical services.

**NEC 250.32(A)** Buildings supplied by a branch circuit or feeder shall have an equipment grounding conductor run with the supply conductors and connected to the grounding electrode system at the separate building.

## GROUNDING and BONDING: CONTINUED

An equipotential bonding grid to mitigate step and touch voltage potential shall be installed at outdoor swimming pools, spas and hot tubs, livestock areas, and at electrical equipment installed outdoors adjacent to natural and artificially made bodies of water.

## UNDERGROUND WIRING

**NEC 300.5** Direct buried cable or conduit or other raceways shall meet the following minimum cover requirements:

Direct Burial Cable	Rigid or Intermediate Metal Conduit	Non-Metallic Raceway (PVC)
24 inches	6 inches	18 inches
Residential branch circuits rated 20 amps or less at 120 volts or less and with GFCI protection at their source are allowed a minimum cover of 12 inches		

**NOTE:** This table does not apply to underground wiring at outdoor pools, spas, or hot tubs see NEC Article 680

NOTE: Residential branch circuits rated 20 amps or less at 120 volts or less and with GFCI protection at their source are allowed a minimum cover of 12 inches.

**NEC 300.5(D)(3)** Underground service laterals shall have their location identified by a warning ribbon placed in the trench at least 12" above the underground installation.

**NEC 300.5(J)** Where subject to ground movement, direct buried cables and raceways shall be installed with expansion capability to prevent damage to the enclosed conductors or to the connected equipment.

**NEC 110.14(B)** Wire splicing means for direct burial conductors shall be listed for such use.

**NEC 300.5(D)(1)** Conductors emerging from underground shall be installed in rigid metal conduit, intermediate metal conduit, or Schedule 80 rigid nonmetallic conduit from 18" below grade or the minimum cover distance to the point of termination above ground. The bottom of the pipe shall be protected by a bushing or other effective means.

**NEC 680.10** Underground wiring is not permitted under pools or within 5-feet horizontally from the walls of the pool, unless supplying permitted pool equipment.