Basic Requirements for Residential Electrical Installations

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This brochure is intended to be a general overview of and does not include all residential electrical requirements. A thorough review of the applicable sections of the 2017 National Electrical Code (NEC) as well as the 2019 Residential Code of Ohio with any amendments is recommended prior to the start of your project.

Please Be Advised

While it may be acceptable for homeowners to perform their own electrical installations, it may not be advisable. If you do not have a working knowledge of electrical energy, current installation standards, and wiring methods or materials, we recommend you contact a licensed electrical contractor to perform your installation.

Required Inspections

Trench inspection for underground electrical conduit/cable is performed to verify the correct depth for the given application. A trench inspection is performed prior to backfill with or without the conduit/ cable installed.

Service inspection is performed once the basic electrical service equipment is installed. Service equipment would include: Service Entrance Cable or Conductors, Conduit (If applicable), Meter Base, Load Center, Grounding Electrode System.

Rough-In inspection is performed prior to insulating or covering the wall/ceiling framing. Rough-in inspection is performed to verify that the wiring method(s) have been installed correctly for the given application. Outlet/junction boxes should be installed and connected by all needed conduit/cabling including the home runs back to the load center. All outlet/junction boxes should be made-up, bonded and ready to be covered or have their devices installed.

Final Inspection is performed once the electrical system is completely installed and functional. Final inspection is performed to verify the correct device installation, overcurrent protection, and overall system function.

Small Conductor Capacities

Fuse/Circuit Breaker Size	Minimum Wire Size NM Copper Cable	Minimum Wire Size SER Aluminum Cable
15 Amp	14 AWG	N/A
20 Amp	12 AWG	N/A
30Amp	10 AWG	N/A
40 Amps	8 AWG	8 AWG
50 Amps	6 AWG	6 AWG

General Installation Requirements

NEC 110.3. All electrical equipment is to be installed according to it's product listing. Considerations such as physical location, mechanical strength, voltage, current capacity, and working space should be taken into account prior to the purchase and installation of electrical equipment.

NEC 110.12. Any unused openings in boxes are to be closed to maintain the integrity of the box.

NEC 110.14. Equipment wire terminals are listed for the type of wire (aluminum, copper) they will accept. Unless otherwise marked, terminals are usually listed for only one wire termination. The temperature limitation of the terminal should be taken into consideration when choosing the circuit conductor. Conductors are to be spliced with a listed mechanical splicing device (wire nut, splice cap, split bolt, H-tap, etc.) and insulated equivalent to the conductor's original insulation. Wire connectors used underground are to be listed for direct burial.

* Oxide inhibiting compound is recommended for aluminum wire terminations.

NEC 110.26. The clear working depth in front of equipment is to be at least 36" measured from the front of the box. The clear working height in front of the equipment measured from the floor is to be either at least 78" or to the top of the box which ever is greater. The clear working width in front of equipment is to be at least 30" or the width of the box which ever is greater. The space equal to the width and depth off the equipment and extending from the floor either to a height 6' above the equipment or to the structural ceiling, whichever is lower, shall be dedicated to the electrical installation. No piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation is to be located in this zone.

NEC 200.7. Grounded conductors (neutral) with white insulation may be re-identified by color and used as ungrounded/hot conductors, but may not be used as a return conductor from a switch to an outlet.

Branch Circuit Requirements

NEC 210.4. Conductors of a multi-wire branch circuit are to be grouped together and connected to a two-pole circuit breaker.

NEC 210.8. Ground Fault Circuit Interrupter (GFCI) protection is to be installed in a readily accessible location and is to be provide for all 125 volt, 15-20 amp *receptacles* located in the following areas of the home/property: Bathrooms; Garages/Accessory buildings (Sheds, Freezer Buildings, Pole Buildings); Outdoors; Crawl Spaces; Unfinished Basements; Kitchens (Serving the Countertop); Sinks *(Within 6' of the basin in any direction) (A GFCI receptacle located in the back of the sink cabinet is NOT considered readily accessible for reset or testing);* Boathouses; *Bathtub/shower stalls (Within 6' of fixture edge); Laundry Areas:*

Ohio Exceptions: Garage door openers may be supplied by a single receptacle, ceiling mounted without GFCI protection; Basement sump pumps may be supplied by a single receptacle without GFCI protection provided a standard GFCI protected duplex receptacle is installed within 6'.

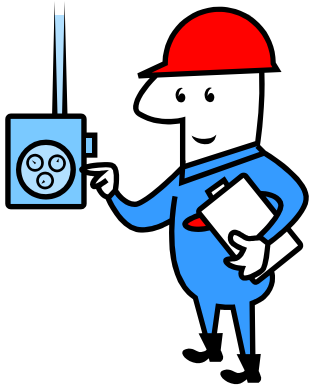
NEC 210.11. In addition to specific appliance and equipment loads, the following circuits are to be provided: General light and receptacle loads are to be calculated at 3 watts per square foot; A minimum of two 20 amp branch circuits shall be installed to supply receptacles on the kitchen counters, kitchen, dining room, and pantry; One 20 amp circuit to supply receptacles in the laundry room with no other outlets; One 20 amp circuit to supply receptacles in the bathroom(s) with no other outlets; One 20 amp circuit to supply the garage receptacles (whether attached or detached) with no other outlets.

NEC 210.12. Arch Fault Circuit Interrupter (AFCI) protection is to be provide for all 125 volt, 15-20 amp branch circuits supplying *outlets or devices* located in the following areas of the home: *Kitchens;* Family Rooms; Dining Rooms; Living Rooms; Parlors; Libraries; Dens; Bedrooms; Sunrooms; Recreation Rooms; Closets; Hallways; *Laundry Area(s);* Rooms/Areas Similar to Those Listed. AFCI protection is required for branch circuit modifications, extensions or replacements in the areas listed above. The AFCI protection device is to be listed as *Combination-Type*.

Ohio Exception: *Kitchen receptacles that serve the kitchen countertop only, do not require AFCI protection, but they need to have GFCI protection.*

NEC 210.52. Kitchens, family rooms, dining rooms, living rooms, parlors, dens, sunrooms, bedrooms, recreation rooms, or similar areas are to have receptacles placed on walls 2' long or longer. Wall spaces are measured around corners and along the floor line including: fixed exterior wall panels, fixed room dividers, free-standing counters, and railings. Receptacles are to be placed so that no point along the wall line is greater than 6' from a receptacle outlet. Receptacles are to be installed on any kitchen counter space longer than 12", and no point along the countertop measured at the wall is to be greater than 24" from a receptacle outlet. Kitchen islands and peninsula countertops 24" or longer are to have at least one receptacle outlet. Bathrooms are to have at least one receptacle outlet installed within 36" of the sink. At least one receptacle outlet is to be installed outside at each of the front and back of the house, on decks, balconies, porches, within 25' of HVAC equipment, and at accessory buildings with electric power. At least one receptacle outlet is to be installed in the laundry area, each unfinished basement area, and hallways 10' or more in length. Foyers (not part of a hallway described above) greater than 60 ft^2 shall have a receptacle located in each wall space 3' or more in width. Each car space in a garage shall have a receptacle which is part of the 20 amp circuit required by 210.11. All receptacles located in the areas above, within 66" of the finished floor are to be tamper-resistant.

Basic Service Requirements



NEC 310.15(B)(7). *Service and feeder conductors supplied by a single phase, 120/240 volt system rated 100 through 400 amperes and serving each individual dwelling unit of one-, two-, and multi-family dwellings; shall have an ampacity not less than 83% of the service rating. The table below gives the smallest size conductor before any adjustment or correction factors are applied. The de-rating does not apply to conductors for the total supply of power to two-family dwellings, multi-family dwellings, or other than dwelling installations.*

Service Rating Fuse/Circuit Breaker	Minimum Wire Size Copper Cable	Minimum Wire Size Aluminum Cable
100 Amp	4 AWG	2 AWG
150 Amp	1 AWG	2/0 AWG
200 Amp	2/0 AWG	4/0 AWG
300 Amp	250 AWG	350 AWG
400 Amp	400 AWG	600 AWG

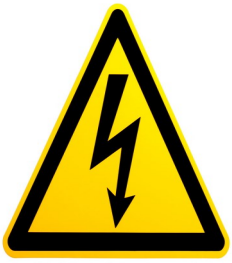
NEC 230.70. Service disconnects are to be readily accessible on the outside of the home or inside nearest the point of entrance of the service conductors. Service disconnects shall be suitable for the prevailing conditions. Service disconnects cannot be located in a bathroom.

NEC 230.71. A service can consist of up to six switches or circuit breakers grouped together and when combined do not exceed the rating of the service.

NEC 240.24. Circuit breakers/fuses are to be readily accessible with the upper most operating handle not more than 6'-7" above the finish floor. Circuit breakers/fuses are not to be located in bathrooms, over steps of a stairway, or in the vicinity of easily ignitable material such as in a clothes closet.

NEC 338.12(B) Underground service entrance cable a.k.a. "URD" (Type USE/USE-2) cannot be installed inside a structure. USE/USE-2 cable must terminate immediately upon entering the structure or convert to an interior wiring method.

Basic Grounding and Bonding Requirements



NEC 250.24. A grounded AC service is to have a grounding electrode conductor (GEC) connected to the terminal or bus to which the grounded service conductor (service neutral) is connected. This connection point is to be in one location only and at any accessible point between the service point and the service disconnect.

NEC 250.24 A main bonding jumper (screw, wire, strap) is to be installed a the main service disconnect. The main bonding jumper is to connect the service enclosure, the grounding electrode conductor, the equipment grounding conductor(s) (EGC), and the grounded service conductor (service neutral) together.

NEC 250.32. Accessory buildings supplied by branch circuits and/or feeders are to have a grounding electrode system installed and connected to the equipment grounding conductor, which is installed with the branch circuit or feeder.

NEC 250.50. All grounding electrodes present at each building or structure are to be bonded together to form a grounding electrode system. If no electrode exists, a grounding electrode system is to be installed.

NEC 250.53. Minimum Grounding Electrode Systems Commonly Installed

- Two, 8' ground rods 5/8" diameter (unless listed), bonded together, and installed at least 6' apart
- One internal or external metal well casing.
- Two, 5/8" x 8' ground rods (Unless listed) and one metal water line (10' or longer).
- 20' bare copper conductor not smaller than 4 AWG installed in a horizontal footing in direct contact with earth surrounded by a minimum of 2" of concrete (New Home).
- One 1/2" x 20' bare or zinc galvanized rebar installed in a horizontal footing in direct contact with earth surrounded by a minimum of 2" of concrete (New Home).

NEC 250.64. The grounding electrode conductor is the wire that connects the grounding electrode system to the service equipment. This wire is to be installed in one continuous piece. The grounding electrode conductor is to be protected from damage where needed by PVC conduit. Any conduit used to protect a grounding electrode conductor is to be PVC conduit. The grounding electrode conductor shall be solid or stranded, copper, insulated, covered, or bare.

NEC 250.66. Ground Electrode Conductor Sizing.

Copper Service Entrance Conductor Size	Aluminum Service Entrance Conductor Size	Ground Electrode Conductor Copper Cable Size
#2 or smaller	1/0 or smaller	8 AWG
#1 or 1/0	2/0 or 3/0	6 AWG
2/0 or 3/0	4/0 or 250	4 AWG
4/0 to 350	250 to 500	2 AWG
350 to 600	500 to 900	1/0 AWG
600 to 1100	500 to 900	2/0 AWG

Note: If multiple sets of service entrance conductors are connected to a service drop, set of overhead conductors, set of underground service conductors, or service lateral; the equivalent size of the largest service entrance conductors shall be determined by the largest sum of the areas of the corresponding conductors of each set.

NEC 250.94. At the service equipment, an intersystem bonding termination bar or an exposed 6 AWG or larger copper wire is to be provided to accommodate bonding requirements of other systems (Cable TV, Telephone, Satellite, etc.).

NEC 250.104. Water piping systems, gas piping systems, exposed structural steel, or any other exposed metallic structures or equipment likely to become energized is to be bonded to the equipment grounding system.

NEC 250.66. If the grounding electrode conductor is only connected to rod, pipe, or plate electrodes, or any combination thereof, the grounding electrode conductor shall not be required to be larger than 6 AWG copper.

Basic Wiring Methods

NEC 300.3. All conductors of the same circuit, including the grounded conductor (neutral) and the equipment grounding conductor, are to be installed in the same conduit, cable, or trench.

NEC 300.4. Cables and raceways are to be protected from physical damage. Cables and raceways in wood construction are to be installed parallel with the framing or through bored holes at least 1-1/4" from the outside edges of the stud, and 2" from the top or bottom of floor and ceiling joists. Where the 1-1/4" clearance cannot be maintained, 1/16" metal protector plates are to be installed. Conduits containing insulated conductors 4 AWG and larger are to have identified fittings providing a smoothly rounded insulating surface installed at each end to protect the conductors.

NEC 300.5. Minimum cover from grade to top of pipe requirements for underground electrical wiring.

- Direct Bury Cable = 24" (18" Under Residential Driveway)
- Single Branch Circuits, 20 amps, 120 volts, and GFCI protected = 12"
- Rigid Metal Conduit = 6" (18" Under Residential Driveway)

The interior of enclosures or raceways installed underground are considered to be a wet location.

NEC 300.5. Direct bury cables/conductors are to be protected by conduit starting at 18" below grade and extend up to the box or enclosure. Underground service conductors are to be identified by a warning ribbon placed at least 12" above the conductors/cable/conduit. Direct bury cables/conductors are to be protected from earth movement by "S" loops buried below the point where they emerge from grade. Direct bury conduit is to be protected from earth movement by expansion fittings installed above the point where it emerges from grade. A bushing or terminal fitting with a bushed opening shall be used at the end of a conduit or other raceway that terminates underground where the conductors or cables emerge as a direct burial wiring method.

NEC 300.22. NM cable, MC Cable, and EMT conduit can pass through but <u>not</u> terminate in stud and joist spaces used to carry environmental air.

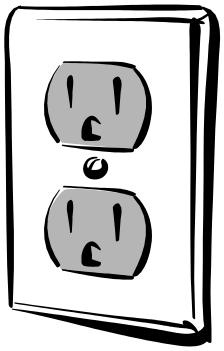
NEC 314.4. Metal boxes are to be bonded to the equipment grounding conductor(s).

NEC 314.16. *In general*, a standard outlet box can accommodate three 14/2 NM or two 12/2 NM cables and a device per "gang".

NEC 314.17. The outer jacket of NM/UF cable shall extend at least 1/4" into junction and outlet boxes.

NEC 314.27. Ceiling boxes used to support paddle fans or large light fixtures are to be listed and rated for the weight of the fan or light.

NEC 406.4. Non-grounding type receptacles (two-prong) can be replaced by a non-grounding type receptacle, a grounding type (three-prong) GFCI receptacle, or a grounding type (three-prong) GFCI *protected* receptacle without an equipment grounding conductor connection. "No Equipment Ground" and/or "GFCI Protected" labels shall be used in the location of the replaced receptacles where appropriate. When a receptacle is replaced in an area requiring AFCI protection. AFCI protection is to be provided for the new receptacle. Replacement receptacles in damp and wet locations are to be list as weather resistant. Replacement receptacles are required to be tamper-resistant when lower than 66" above finished floor except where a non-grounding type receptacle is used.



NEC 406.9. Receptacles <u>not</u> located under an overhang, canopy, or otherwise protected form the weather are to have an "in-use" , *a.k.a "box hood" or "bubble"* cover installed to protect the cord connection. The cover is to be listed for "extra duty" use. Receptacles are not to be installed within or directly over a bathtub or shower stall.

NEC 406.12. All 15-20 ampere, 125—250 volt non-locking type receptacles shall be listed tamper-resistant when lower than 66" above finished floor.

NEC 408.41. Unless otherwise listed, the neutral terminal bar in a panelboard is to have only one wire terminated per screw/hole.

<u>Basic Lighting Requirements</u>

NEC 210.70. At least one switch-controlled lighting outlet is to be installed in every habitable room, kitchen, bathroom, stairway, hallway, garage (with electric power), storage and equipment space, and outside every exterior entrance/exit door. Stairway lighting is to have a switch at every level or landing.

NEC 410.2. Light fixtures installed in clothes closets are to be placed directly above the closet door.

NEC 410.10. Only recessed lighting fixtures with a gasketed lens/cover can be installed over or within 3' of a shower or bathtub.

NEC 410.16. Lighting fixtures in clothes closets are to be enclosed or florescent lamps.

NEC 410.42 Lighting fixtures are to be grounded.

NEC 410.44. Replacement lighting fixtures installed on an existing two-wire branch circuit with no equipment grounding conductor are to be GFCI protected.

NEC 410.116. Thermal insulation shall not be installed above or within 3" from recessed light fixtures (Can Lights) unless the fixture is rated for insulation cover ("IC").

NEC 410.151. Track lighting is not to be installed in damp or wet locations.