

Wiring Guidelines – Single Family Residential

This guide has been prepared to assist the lay person in complying with the requirements of all Larimer County adopted Electrical Codes and assure the installation of a safe and reliable electrical system. This guide is **NOT** all-inclusive for every installation and it is not an instruction manual.

Along with meeting NEC requirements, the permit and inspection process defined by ordinance must be followed. In general, **one permit is normally required for the construction of a new home, to include wiring of the home and temporary construction service (if temporary power is necessary)**. The electrical inspector will normally only make two inspection visits on a residential permit, **one for the rough-in and temporary heat**, and **one for the final inspection**. The temporary heat inspection is for the main service of the dwelling and requires the installation of the service equipment, associated grounding electrode system, at least 1 GFCI-protected receptacle outlet, and the connection of the heat source (if possible). This inspection will be performed in conjunction with the rough-in inspection of the house wiring for no additional charge. A fee for an additional inspection is required if performed separately. If for some reason the job does NOT meet the requirements of the NEC and an extra visit is necessary, a re-inspection fee may be required and must be paid prior to re-inspection.

SERVICES

The service equipment must be large enough to supply the connected load, which is calculated using Article 220 of the NEC. The most common sizes of residential service equipment are 100, 125, 150, and 200 amperes. The minimum wire sizes for service conductors are listed below:

Three-Wire, Single-Phase Dwelling Services & Four-Wire Feeds on Main Feeder - Service only, does not apply to any sub-panel after building main panel.

Conductor Types and Sizes

RHH,RHW,RHW-2,THHN,THHW,THW,THW-2,THWN,THWN-2,XHHW,XHHW-2, SE, USE, USE-2

Type USE (Underground Service Entrance) conductors are not permitted to enter a building unless they are also identified with the additional markings RHH and RHW (triple-rated).

Service Rating	Copper	Aluminum
	AWG	AWG
100	4	2
125	2	1/0
150	1	2/0
200	2/0	4/0
225	3/0	250 kcmil

For services over 225 Amperes, please call the Larimer County Building Division.

LOCATION OF MAIN SERVICE EQUIPMENT AND PANELS

The main disconnect or panel shall be mounted outside. All service equipment and electrical panels shall have a clear area 30" wide and 36" deep in front of the equipment. This clear area must extend from the floor to ceiling with no intrusions from other equipment, cabinets, counters, appliances, pipes, etc. Applies to service only, not feeder disconnectors/panels.

Service equipment/panels are not allowed in a clothes closet, bathroom, or over steps.

GROUNDING REQUIREMENTS

The service equipment must be grounded in accordance with Article 250 of the NEC, which, in general, says that the neutral must be bonded (electrically connected together) to the service enclosure and the grounding electrode system as defined in NEC **Article 250.50**:

250.50 Grounding Electrode System. All grounding electrodes as described in 250.52(A)(1) through (7) that are present at each building or structure served shall be bonded together to form the grounding electrode system. The grounding electrodes permitted in 250.52 are (1) Metal Underground Water Pipe

(2) Metal Frame of the Building or Structure (3) Concrete-Encased Electrode (4) Ground Ring (5) Rod and Pipe Electrodes (6) Other Listed Electrodes (7) Plate Electrodes. Grounding electrode conductors must be sized in accordance with **Table 250.66**.

NOTE: The NEC requires a concrete-encased electrode to be installed on all new installations. This must be installed when the footings are installed. Concrete isolated from contact with soil by foam forms, insulation, plastic sheeting, or similar materials is NOT considered in contact with the earth.

250.52(A)(3) Concrete-Encased Electrode. An electrode encased by at least 2 inches of concrete, located horizontally near the bottom or vertically, and within that portion of a concrete foundation or footing that is in direct contact with the earth, consisting of at least 20 feet of one or more bare or zinc galvanized or other electrically conductive coated steel reinforcing bars or rods of not less than ½ inch in diameter, or consisting of at least 20 feet of bare copper conductor not smaller than 4 AWG. Reinforcing bars shall be permitted to be bonded together by the usual steel tie wires or other effective means. Where multiple concrete-encased electrodes are present at a building or structure, it shall be permissible to connect to only one.

In the main service equipment, the neutral and equipment grounding conductors are bonded (connected) together; in sub-panels, the neutral is isolated from the equipment ground.

Each branch circuit or feeder to a building or structure must include an equipment grounding conductor. In rural areas, please check with your local inspector for specific requirements regarding underground service conductors from the meter pole or pedestal to the main service. Where there is an overcurrent device in the pedestal or on the meter pole, an equipment ground is required with the feeder conductors. Other specific provisions of Article 250.32 may also apply.

All underground wiring must be inspected prior to covering. NOTE: If the open trench creates a hazard or an obstruction, (i.e. across a road), you must call your inspector and request permission to cover *only as much of the underground installation prior to inspection as may be necessary* to eliminate the hazard or restore access. The general rule is any portion of the electrical installation which is to be concealed **must** be inspected prior to concealment. Nothing should ever be concealed without first consulting with your local inspector. Uncovering work covered without inspection is destructive, time-consuming, and expensive.

BRANCH CIRCUIT WIRING

Type NM cable (aka Romex®) is the wiring method most used in residential dwellings. NM cable must have a 90° conductor insulation rating, which is designated on the cable sheath by a "B". Type NM-B #12 and #14 are used for lighting and general purpose receptacle circuits, while #10/2 w/ground is commonly used for electric water heaters, #10/3 w/ground for electric dryers, and #8/3 w/ground and #6/3 w/ground for ranges and wall mounted ovens. Type SER cable with an insulated neutral is permitted for electric ranges, wall ovens and dryers. These cables must be protected by overcurrent devices (circuit breakers) which do not exceed the 60° ampacity. The rated ampacities for common cable types are listed below:

COPPER NM CABLE

15 amperes for #14
20 amperes for #12
30 amperes for #10
40 amperes for #8
50 amperes for #6

TYPE SE AND SER ALUMINUM CABLE

30 amperes for #8
40 amperes for #6

SE cables not limited to 60° column IF all terminations are rated 75° or greater, use 75° column.

It is important to note that if you begin a circuit with #12, you must use this same wire size throughout, you CANNOT mix different wire sizes on the same branch circuit.

Type NM cable must be stapled within 12" of any boxes with cable clamps, 8" of single-gang plastic boxes without clamps, and every 4½ feet thereafter. Listed connectors must be used where NM cables enter cabinets, metal boxes or panel boards. The ampacity of conductors in NM cables shall be derated in accordance with Table 310.15(B)(3)(a) where *more than 2* cables are placed in a single hole that is fire- or draft-stopped **or** are installed, without maintaining spacing, in contact with thermal insulation.

When Type NM cable is installed parallel to framing members, or in bored holes, it shall be located at least 1¼" from the nearest edge of the framing member, where nails or screws may penetrate the cables. If this distance cannot be maintained, the cable shall be protected by a steel plate or sleeve at least 1/16" thick. **Article 300.4(A)(1).**

Cable or raceway-type wiring methods installed in a groove, to be covered by wallboard, siding, paneling, carpeting, or similar finish, shall be protected by 1/16" thick steel plate, sleeve, or equivalent, or must be recessed in the groove 1-1/4" for the full length of the groove in which the cable or raceway is installed. *Exception: Raceways as covered in Articles 342, 344, 352, and 358.* **Article 300.4(E).**

Ceiling-mounted paddle fan outlet boxes or outlet box systems used as the sole support shall be listed, shall be marked by their manufacturer as suitable for this purpose, and shall not support fans weighing more than 70 lbs. For boxes used to support fans weighing more than 35 lbs., the required marking shall include the maximum weight to be supported. **Section 314.27(C), NEC.**

Where spare, separately- switched, ungrounded conductors are provided to a ceiling-mounted outlet box in a location of adequate area for the installation of a ceiling-suspended (paddle) fan, the box must be an approved ceiling fan box. **Section 314.27(C)**. Ceiling boxes in locations acceptable for paddle fan installation shall have fan rated boxes utilized.

REQUIRED BRANCH CIRCUITS

(a) Small Appliance Branch Circuits – The NEC requires a minimum of two 20-ampere branch circuits to supply receptacle outlets for small appliance loads, including refrigeration equipment, in the kitchen, pantry, breakfast room, and dining room. These circuits, whether two or more are used, shall NOT supply anything other than receptacles in these areas. Lighting outlets and built-in appliances such as garbage disposals, exhaust hoods, microwaves, dishwashers, and trash compactors are NOT permitted on these circuits. Kitchen countertop receptacles must be supplied by these small appliance branch circuits. *Exception: The receptacle outlet for refrigeration equipment shall be permitted to be supplied from an individual branch circuit rated 15 amperes or greater.*

(b) Laundry Branch Circuit – One 20-ampere branch circuit must be provided for the laundry. This circuit is limited to receptacles within the laundry room. No other outlets or lighting is permitted on this circuit.

(c) Bathroom Branch Circuit – At least one 20-ampere circuit for bathroom receptacle outlets shall be supplied. Such circuits may have no other outlets. *Exception: Where the 20-ampere circuit supplies a single bathroom, outlets for other equipment within the same bathroom shall be permitted to be supplied in accordance with 210.23(A)(1) and (A)(2).* This circuit would NOT be used to supply a whirlpool bath or a hot tub!

(d) Central Heat – Central heating equipment shall be supplied by an individual branch circuit.

(e) General Lighting Branch Circuits – Shall be computed on a three watts per square foot basis. You may wire up to 600 square feet of living area on a 15-ampere branch circuit or up to 800 square feet on a 20- ampere circuit. These branch circuits may supply lighting outlets in all areas of the dwelling and receptacle outlets, other than those covered in (a) - (d) above.

Arc-Fault Circuit Interrupter (AFCI) Protection – All 120-volt, single-phase, 15- and 20-ampere 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 areas shall be protected by any of the means described in 210.12(A)(1) through (6), more commonly a listed, combination-type AFCI breaker or a listed branch-feeder type AFCI breaker used in combination with a listed outlet branch circuit type AFCI receptacle. In dwelling units, in any of the above areas where a branch circuit is modified, replaced or extended, AFCI protection shall be provided. **Article 210.12(B)**. Arc-fault circuit interrupters shall be installed in a readily accessible location. Garage branch required.

210.11 (G)(4) REQUIRED RECEPTACLE OUTLETS

For dwelling units, in all areas specified in 210.52, all 125-volt, 15- and 20-ampere receptacles shall be listed tamper-resistant receptacles.

All 15- and 20-ampere, 125-volt non-locking receptacles located in damp or wet locations shall be a listed weather-resistant type.

(a) At least one outlet shall be installed in bathrooms within 36 inches of the outside edge of each basin. The receptacle outlet shall be located on a wall or partition that is adjacent to the basin location, no more than 12" below countertop.

(b) At least one outlet in each car space shall be installed in each attached garage, and in each detached garage with electric power. The garage branch circuit shall not supply outlets outside of the garage. Any receptacles installed specifically for electric vehicles shall be supplied by a separate branch circuit having no other outlets. Exception to supply readily accessible exterior receptacles.

(c) At least two outlets shall be installed outdoors, one on the front and one on the back of the dwelling, accessible at grade level. Outdoor outlets installed in wet locations shall have an enclosure that is weatherproof whether the attachment plug cap is inserted and shall be identified as "extra duty". Balconies, porches, and decks that are attached to the dwelling unit and are accessible from the interior shall have at least one outlet installed within the perimeter of the balcony, porch or deck.

(d) At least one receptacle must be installed in each unfinished portion of the basement. This receptacle is in addition to any receptacles that may be installed for laundry or other specific purposes.

(e) In every kitchen, family room, dining room, living room, parlor, library, den, sun room, bedroom, recreation room or similar room, or area of dwelling units, receptacle outlets shall be installed so that no point along the floor line in any wall space is more than six feet horizontally, measured from an outlet in that space, including any wall space, two feet or more in width, and excluding only that space occupied by sliding panels in exterior walls. The wall space afforded by fixed room dividers, such as freestanding bar-type counters, or railings, shall be included in the six-foot measurement (Generally stated, this means the first receptacle would be placed within 6 feet of the doorway and the next one within 12 feet of the first one and so forth around the room until you reach another doorway or break in the wall, where you would then need a receptacle within 6 feet of that doorway or break). No outlet may be installed over an electric baseboard heater. These measurements are to be made horizontally along the wall at floor line. Separate wall spaces 2 feet wide or more require a receptacle on them.

(f) In kitchens and dining areas, a receptacle outlet shall be installed at each counter space 12" or wider. Countertop receptacles shall be installed so that no point along the wall line is more than 24", measured horizontally from a

receptacle outlet in that space. Peninsular countertops and islands 12" or wider shall have at least one receptacle. (This rule is applied similarly to the 6-12-2-foot dimensions in (e) above except that in the kitchen the dimensions are 24-48-12 inches beginning at each end of the countertop.)

(g) Receptacles installed in the floor must be installed in a listed floor box. These may be purchased as an assembly at most retail electrical supply stores. Receptacles installed in the floor within 18" of the wall may be used in place of wall-mounted receptacles.

(h) A receptacle outlet is required in any dwelling unit hallway that is ten feet or more in length.

(i) At least one 15- or 20-ampere, 125-volt GFCI-protected receptacle must be installed at an indoor spa or hot tub location, not closer than six feet from the inside wall of the unit and not more than ten feet away from it. Light fixtures, outlets and ceiling fans over spas and hot tubs shall be a minimum of 7'6" above the maximum water level. Outdoors spa or hot tubs have the same requirements as a swimming pool. Check with your local inspector for those requirements.

(j) A 125-volt, 15- or 20- ampere receptacle outlet shall be installed at an accessible location for the servicing of heating, air-conditioning, and refrigeration equipment. This outlet shall be located on the same level and within 25 feet of the equipment. This includes roof-mounted equipment. A receptacle outlet shall **NOT** be required for the service of evaporative coolers for one- and two-family dwellings.

(k) Foyers that are not part of a hallway and are larger than 60 sq. ft. shall have receptacles installed in each wall space 3ft. or more in width and unbroken by doors, floor-to-ceiling windows, and similar openings.

REQUIRED LIGHTING OUTLETS

(a) At least one wall switch-controlled lighting outlet shall be installed in every habitable room: in bathrooms, hallways, stairways, attached garages, detached garages with electric power and at outdoor entrances or exits with grade-level access. The lighting outlet for interior stairways shall have a wall switch at each floor level, and landing level that includes an entryway, to control the lighting outlet(s) where the difference between floor levels is six steps or more.

(b) At least one wall-switch controlled lighting outlet shall be installed in an attic, under floor space, utility room, and basement, where these spaces are used for storage or contain equipment requiring servicing. The switch shall be located at the point of entry to these areas, and the lighting outlet located at or near the equipment requiring servicing.

GROUND-FAULT PROTECTION

A ground-fault circuit interrupter (GFCI) must protect ALL receptacles listed below:

(a) Bathroom receptacles

(b) Garages, and 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.

(c) Outdoors with the following exception:

(1) Receptacles that are not readily accessible and are supplied by a dedicated branch circuit for electric snow-melting or deicing equipment shall be permitted to be installed in accordance with 426.28.

Please check with your local inspector for more information.

(d) Crawl spaces – at or below grade level

(e) All receptacles in basement with the following exception:

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

(f) Kitchens – where the receptacles are installed to serve the countertop surfaces.

(g) Dishwashers

(h) Sinks – where the receptacles are installed within 6 feet of the outside edge of the sink.

(i) Boathouses

(j) Bathtubs and shower stalls – where receptacles are installed within 6 feet of the outer edge of the tub or stall

(k) Laundry areas

(l) Hydromassage bathtubs

(m) Spas and Hot tubs and associated electrical components

(n) Ground-fault circuit interrupters shall be installed in a readily accessible location

(o) Indoor damp & wet locations

(p) Crawlspace lighting

REQUIRED DISCONNECTING MEANS

Disconnects are required in-sight of the following equipment:

(a) Electric water heaters

(b) Well pump controllers

- (c) Central heating equipment (furnaces, boilers)
- (d) Spas and hot tubs (minimum of 5' from edge of hot tub)
- (e) Hydromassage bathtubs
- (f) Appliances

(For cord-and-plug connected appliances, an accessible plug and receptacle may serve as the disconnecting means.)

CONDUCTOR FILL

Outlet and junction boxes shall be of sufficient size to provide free space for all conductors and devices enclosed in the box. All outlet boxes have a specific volume, measured in cubic inches. For example, if you have two #12/2 with ground NM-B cables entering a box with one duplex receptacle; you would need a box with a minimum volume of 15.75 cubic inches. Each #12 that enters the box needs 2.25 cubic inches except for the equipment grounding conductors which are counted as one 2.25 cubic inch deduction for all. Also, each strap containing one or more devices is counted as the equivalent of two conductors: therefore, $2.25 \times 7 = 15.75$.

VOLUME REQUIRED PER CONDUCTOR

#14 - 2 cubic inches	#8 - 3 cubic inches
#12 - 2.25 cubic inches	#6 - 5 cubic inches
#10 - 2.5 cubic inches	

EQUIPMENT GROUNDING CONDUCTOR MAKE-UP

All equipment grounding conductors must be connected together with solderless pressure connectors such as wire nuts or crimp sleeves, leaving sufficient extra conductor for attachment to the metal box and/or device. When crimp type connectors are used, they must be crimped using the tool recommended by the manufacturer. Please note that ALL metal junction and outlet boxes must be grounded by attaching the equipment grounding conductor to the metal box using an approved screw or grounding clip. When ALL conductors are made-up (or spliced), a minimum of **six** inches of free conductor must be left for use in make-up and for the attachment of devices. No connector may be cut shorter than 6", measured from back of box. This includes all grounding conductors.

ELECTRIC HEAT CIRCUITRY

Electric heat may be installed on 15, 20, or 30-amp branch circuits. Listed below is the maximum wattage that may be installed on each size branch circuit. (All circuits are figured at 240 volts)

15A - 2,880 watts maximum
 20A - 3,840 watts maximum
 30A - 5,760 watts maximum

For example, if you are installing baseboard heaters which are rated 250 watts per linear foot, you could install 15 feet on a 20-ampere, 240-volt circuit. $250W \times 15 = 3,750$ watts.

ROUGH INSPECTION

At the time you call for your rough inspection, you should have all wire pulled, stapled properly, and all splices made-up and ready to accept devices and fixtures. Please **DO NOT** install any devices or fixtures or cover any wiring with insulation or wall coverings, i.e., drywall, or paneling. **All wire splices and equipment grounding conductor splices shall be completed prior to the rough inspection.**

FINAL INSPECTION

The electrical installation should be complete at the time of request; all devices and fixtures must be installed, service equipment complete and labeled properly. All wiring shall be free from short circuits, ground faults and open circuits. All light fixtures, switches, and receptacles are required to be ground

