JEFFERSON COUNTY COLORADO | Building Safety

100 Jefferson County Pkwy, Golden CO 80419-3540
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RESIDENTIAL ELECTRICAL WIRING GUIDE

How to use this document:

- This guide is written to help homeowners and contractors understand and comply with the 2023 National Electrical Code as adopted by the State of Colorado and Jefferson County.
- This document outlines some of the requirements for single family dwelling units.
- Care should always be taken with electrical work, and this document is in no way inclusive of all requirements for every installation.
- Specific article references in the 2023 National Electrical Code (NFPA 70) are shown in brackets [e.g. 250.125] throughout the document. The document can be accessed for free electronically here (requires free registration with NFPA to access).

When is a permit required?

- An electrical permit is required for the construction of a new home, or any new electrical work being performed in the home/dwelling unit or any structure on a property (i.e. garages, sheds, gazebos, etc.) Application can be filed at https://citizenportal@jeffco.us
- The electrical permit can include the construction meter, the wiring of a structure, the temporary building service, and any other electrical installations associated with your home.
- This includes adding to existing circuits and creating new ones.
- Electrical permits require either an eligible homeowner working on their personal residence, or a state licensed master electrician with an electrical contractor license to be the permit holder.

What should I expect for inspections?

Our staff is friendly, knowledgeable, and always ready to help citizens and contractors understand code requirements to finish the job safely.

- Inspections require 1 business days' notice for scheduling.
- For general tips on inspection procedures, see our guide here.
- The last page of this guide has specific instructions and requirements for rough, service and final electrical inspections.

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CONSTRUCTION METER

Construction meters are for running power on a construction site for tools and appliances. This is an optional item based on the needs of your project. If one is installed, the construction meter is required to be a complete service including all necessary grounding/bonding, proper wire sizes, etc.

- Basic Requirements:
  - At least one 120 volt, 15A (amp) or 20A GFCI protected receptacle (any other receptacles, including 240 volts, [any ampere] receptacles shall also be GFCI protected).
  - Receptacles must be weather resistant type and in-use (**extra-duty type)** covers shall be installed. [406.9(B)(1)]
  - The construction meter must be "stand alone" and not attached to the home or another structure on the lot.
    - **Note:** The construction meter cannot be mounted on Xcel's power poles. A ground rod is required at all construction meters served by Xcel Energy, (Xcel also requires a lever bypass style meter housing) but is not required by United Power or CORE Electric.
    - **CHECK WITH YOUR LOCAL SERVICING UTILITY FOR SPECIFIC REQUIREMENTS.**

BRANCH CIRCUIT WIRING:

Type NMB cable (a.k.a. Romex) is the most widely used wiring method in residential dwellings.

- NM cable must have 90 degree C conductor insulation rating which is designated on the cable sheath by a "B" [334.80].
- #14-2 and #12-2 AWG NMB cables are used for lighting and receptacle circuits.
- #10-2 AWG NMB is used for electric water heaters.
- #10-3 AWG with ground is used for dryers and wall mounted ovens and some air conditioning units.
- #8-3 AWG CU with ground and #6-3 AWG CU with ground is used for ranges and cooktop units.

Type SER cable or an approved four-wire cable is required for electrical ranges, cooktops, wall ovens and clothes dryers. [250.134, 250.140 (A)].

- These cables must be protected by overcurrent devices (circuit breakers) which do not exceed their rated ampacity. The rated ampacities for cable types are listed below, based on [240.4(D)]:

Copper (CU) NM Cable	Ampacity
#14 AWG	15A
#12 AWG	20A
#10 AWG	30A
#8 AWG	50A
#6 AWG	65A

SE and SER Aluminum (AL) Cable	Ampacity
#8 AWG	35A
#6 AWG	40A
#4 AWG	55A

*It is important to note, you cannot mix different wire sizes on the same branch circuit. For instance, if you begin a circuit with #12 AWG, you must use the same size wire for the entire circuit.

- Installation:
  - Type NM (aka Romex) cable shall be stapled within 12" of boxes utilizing approved connectors [334.30], and every 4-1/2 feet thereafter.
  - Cable clamps are required to be used when securing cable to metal boxes, lighting outlets, exhaust fans, recessed cans, panels, and subpanels.
  - Cable sheath shall extend not less than ¼" beyond the end of the clamp [314.17B] [334.19]

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REQUIRED BRANCH CIRCUITS:

General Branch Circuit Requirements

- All branch circuits that supply 125 volts, 15- and 20- ampere outlets (inclusive of light fixtures, receptacles, and smoke detectors) installed in all areas of dwelling units shall be protected by a combination arc-fault circuit interrupter listed to provide protection of the entire branch circuit [210.12(A)].
    - EXEMPT AREAS: bathrooms, garages, unfinished basement areas, and outside outlets
- Any existing (old) receptacle outlets (not in the exempt areas) that are extended or modified shall be AFCI protected [210.12(D)].
- All replaced receptacles (not exempt) shall be AFCI protected and tamper resistant. [406.4 (D)(4-5]

Small Appliance Branch Circuits – Provide a minimum of two 20-amp branch circuits to feed receptacles outlets for small appliance loads [210.11(C)(1)], including refrigeration equipment in the kitchen, pantry, breakfast room, and dining room.

- These circuits, whether two or more, are recommended to have only four receptacle openings per circuit [E3901.3] and shall not supply/serve any other receptacle outlets outside the areas listed above. Lighting outlets are not permitted on these circuits.
- 125volt receptacles serving countertop surfaces require AFCI/GFCI protection, other receptacles within 6' of sinks require AFCI/GFCI protection.
- 250volt receptacles require GFCI protection. [210.8(A)]

Dedicated circuits –

- May be required by the manufacturer and are recommended for disposals, dishwashers, electric ranges, wall mounted clothes dryers, electric water heaters, microwaves, freezers, window unit A/C, etc.
    - AC Condensing Units and Mini-Split systems require a dedicated branch circuit.

Laundry Branch Circuit –At least one 20amp branch circuit must be provided for the laundry area.

- This circuit is limited to receptacles within the laundry area only.
    - Lighting outlets are not permitted on this circuit, [210.11(C)(2)].
    - 125volt receptacles require AFCI/GFCI protection. 250volt receptacles require GFCI protection. [210.8(A)

Furnace - A furnace requires a dedicated circuit. [422.12].

Bathroom - Receptacles require a dedicated 20amp branch circuit.

- Two (2) options are available:
    - All receptacles in all bathrooms in the dwelling can be on the same dedicated branch circuit but serve no other receptacle outlets or equipment.
    - All outlets and equipment (i.e. receptacles, lights, fans, etc.) in a single bathroom can be on the same dedicated branch circuit but cannot serve any other outlets. [210.11(C)(3)].

Hydro-Massage Tub - A dedicated branch circuit with GFCI/AFCI protection is required for Hydro-massage bathtubs. [680.71].

Garage – A dedicated 120 volt, 20amp branch circuit is required for garage receptacle outlets.

- There must be one receptacle outlet for each vehicle bay space, and not more than 5-1/2' above the floor level. The circuit may be extended to serve outdoor receptacle outlets that are readily accessible. [210.11(C)(4)].
- GFCI protection is required.
- Electric Vehicle (EV) Charging outlets require a dedicated circuit for at 125V – 250V receptacles [210.8 (A)(2)]

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REQUIRED RECEPTACLE OUTLETS:

- All receptables (including detached garages and accessory buildings) SHALL BE TAMPER RESISTANT RECEPTACLES.
    - *Exception #1. Receptacles located over 5'6" above the floor.*
    - *Exception #2. Receptacles for cord and plug connected appliances [that are not easily moved from one place to another] located in dedicated space(s) (i.e., refrigerators, freezers, etc.).*
- Receptacle outlets must meet the following requirements:
    - On or above the countertop or work surface: On or above but not more than 20" above the countertop or work surface. [210.52(C)(3)(1)]
    - In countertop or work surface: Receptacle assemblies, must be listed for the purpose. [210.52(C)(3)(2)]
    - Hallways 10' or longer shall have at least one (1) receptacle outlet. [210.52(H)]
    - Foyers (not part of a hallway) containing 60 sq. ft. or more in area shall have a receptacle outlet in each wall 3' in width or more unbroken along the floor line. [210.52(I)]
- **Bathrooms** – Receptacles in bathrooms, must be on a 20amp dedicated circuit and have no other outlets. [210.11(C)(3)],
    - At least one (1) receptacle shall be installed adjacent to and within three (3) feet of each basin. [210.52(D)]
- **Garage –** At least one (1) receptacle in every attached garage, detached garage, and accessory building with electric power.
    - A receptacle is required in each vehicle bay space. [210.52(G)(1)]
    - EV Chargers must have a dedicated circuit
- **Outdoors** – At least one receptacle outlet is required in the front and back of the house not more than 6'6" above grade.
    - Any porch, deck, or balcony attached to the dwelling and accessible from the inside of the dwelling requires a receptacle outlet. [210.52(E)(1) & (3)].
    - These receptacles shall be tamper-resistant (TR), and weather resistant type (WR). [406.9(B)].
- **Unfinished Basement Area –** At least one receptacle must be installed in each unfinished basement area and be GFCI protected. [210.52(G)(3)].
- **Kitchen, Family Room, Dining Room, Living Room, Parlor, Library, Den, Sunroom, Bedroom, Recreation Room, or Similar Rooms of Dwelling Units –**
    - Receptacle outlets shall be installed so that no point along the floor line in any wall space is more than six (6) feet measured horizontally (unbroken at the floor line), from a receptacle in that space. Any wall space greater than two (2) feet requires a receptacle outlet. The space occupied by fixed panels shall be included in the measurements. Sliding panels are excluded.
    - The space afforded by fixed room dividers, such as free-standing bar-type counters or railings shall be included in the six (6) foot measurement. [210.52(A)]. Receptacle outlets may not be installed over electric baseboard heaters. [424.9 FPN].
- **Kitchens –**
    - A minimum of two (2) small appliance branch circuits are required.
    - Wall counter space – a receptacle outlet shall be installed at each wall counter space 12" or wider. Receptacle outlets shall be so installed so that no point along the wall line is more than 24" measured horizontally along the wall line to a receptacle outlet.
    - It is recommended that no more than 4 receptacles be installed on a small appliance branch circuit.

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- **Kitchen Islands and Peninsulas –** 210.52(c)(2) Receptacle must be in the countertop and listed for the purpose per 210.52(c)(3)

REQUIRED GFCI PROTECTED RECEPTACLE OUTLETS:

- Ground fault receptacles shall be readily accessible, (not behind furniture, appliances, under/behind cabinet doors, etc.).

- A ground fault circuit interrupter [210.8] must protect all receptacles listed below.
  - All bathroom receptacles
  - All outdoor receptacles and outlets
  - Attached garage and detached garage & accessory buildings with electric power, 150V or less to ground, 50A or less [210.8(F)]
  - Crawlspaces-at or below grade level
  - All receptacles in basements
  - All receptacles within 6' of sinks (kitchen, laundry, utility, mop, wet bar, etc.)
  - All kitchen receptacles serving the countertop (125volt and 250volt)
  - All receptacles in laundry areas (125volt and 250volt)
  - All receptacles within 6' of shower pans and bathtubs
  - Dishwasher receptacles, electric ranges, wall mounted ovens, counter-mounted cooking units, clothes dryers, microwave ovens [210.12 (B)]

REQUIRED AFCI RECEPTACLES [210.12 (B)]

- All 120-volt, single-phase, 10, 15, and 20-amp branch circuits supplying branch circuits or devices in the following locations must be AFCI protected:
  - Kitchens
  - Family Rooms
  - Dining Rooms
  - Living Rooms
  - Parlors
  - Libraries
  - Dens
  - Bedrooms
  - Sunrooms
  - Recreation Rooms
  - Closets
  - Hallways
  - Laundry Areas
  - Similar areas

REQUIRED LIGHTING OUTLETS [210.70]

- Lighting controlled by dimmers in multiple locations shall have the full range of dimming at all locations for interior stairway illumination [210.70(A)(2)(4)]
- **Wall switch-controlled** – At least one lighting outlet controlled by a wall switch must be in habitable rooms, bathrooms, hallways, garages, detached garages with electric power, stairways (switched at every floor level with 6 or more risers), outdoors where it is accessible from inside the dwelling (decks, patios, porches, service doors from garages, etc.).
- **Switch-controlled** – Attics, underfloor spaces, utility rooms, basements (switch to be located at the usual point of entry to these spaces. The lighting outlets shall be located at or near the equipment requiring servicing.

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CONDUCTOR FILL [314.16]:

- 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.
  - This volume must be equal to or greater than the cubic inches required for the number of conductors and devices in the box. (See Table 314.16(B) NEC)
  - Count only as one conductor (the largest) ground/bond wire for all ground wires in the box up to a quantity of 4.
    - A ¼ volume allowance shall be made for each additional EGC installed [314.16 (B) (1)]

Conductor/Device Box Fill	Cubic Inches Required in the Box (per conductor)
Each # 14 AWG	2.0
Each # 12 AWG	2.25
Each # 10 AWG	2.5
Each device counts as	2x the largest conductor in the box

Example:

2 - #12 NMB cables (each cable contains 2 – insulated conductors and 1 bare grounding conductor and 1 duplex receptacle

4 x 2.25 = 9.0 cu. in. (insulated conductors)
1 x 2.25 = 2.25 cu. in (grounding conductor)
1 x 4.50 = 4.50 cu. in. (device equals two conductors)
Total 15.75 cu. in. (minimum size box required)

- Receptacles and switches mounted in boxes shall be installed such that the mounting yoke or strap is held rigidly against the finished surface. [406.5(A)].
  - Screws for mounting devices shall be listed for the device (sheetrock/deck style type screws are not permitted. [404.10(B), 406.5]
  - Boxes shall be mounted so that the front of the box is planned to be not greater than ¼" from the finished face of the wall. If a combustible surface is installed on the wall the box must be flush with the finished surface. [314.20]
  - Gaps or open spaces shall be repaired around the boxes and shall not exceed 1/8" at the edge of the box. [314.21]
  -

EQUIPMENT GROUNDING COUNDUCTORS (EGC's) AND CONDUCTOR MAKE-UP

- All equipment grounding/bonding conductors shall be connected by solder-less 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 shall be installed per manufacturer's installation instructions and crimped using the tool required by the manufacturer. [110.3(B)].
  - ALL conductors shall be a minimum of 6" in length when they exit the front of the box for the attachment of devices.

  - The sheathing shall be a minimum of ¼" inside the box. When a metal box is used, the grounding conductor inside the cable will need to be longer to afford to ground/bond the box. The box shall be

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- bonded by an approved Green 10/32 screw or clip.
- The crimp of the ground wire is correct in the picture above.
- All boxes/outlets shall be "made-up" and ready to take devices.

CALCULATING THE MINIMUM GENERAL LIGHTING/OUTLET REQUIREMENTS

- Reference Tables in Article 220 of the latest edition of the NEC.
  - Minimum unit load 3 volt-amperes/square feet [220.41]
  - One 120volt 15amp circuit per 600 sq. ft.
  - Each 15amp circuit @ 80% = 12amps
  - Each 20amp circuit @80% = 16amps
  - At 1.5 amps per light/outlet = maximum of 8 outlets per 15A circuit
  - If using a 20amp circuit, a maximum of 10 outlets are allowed.
    - Note: these are general rule applications and are not specific to your individual project.

ELECTRIC HEAT CIRCUITRY

- Electric heat may be installed on 15, 20, or 30-amp branch circuits.
- Listed below is the maximum volt/amps that may be installed on each size branch circuit, all circuits are figured at 240volts. [424.3(A)]
  - For example, if you are installing baseboard heaters which are rated 250V/A (Watts) per linear foot, you could install 15 feet on a 20amp 240volt circuit. (250V/A x 15 = 3750V/A)

AMPS	Maximum Volt/Amps (Watts)
15	2880
20	3840
30	5760

SERVICES AND FEEDERS:

- Surge protection is required for services.
- The service equipment must be large enough to supply the connected load.
  - You can find how to calculate the load in Article 220 of the NEC.
    - The most common sizes of residential service equipment is 100 amps (minimum size for a dwelling unit), [230.79], 125 amps, 150 amps, and 200 amps.

Minimum size of service entrance conductors

Service or Feeder Rating (Amp)	Copper (CU)	Aluminum or Copper-Clad Aluminum
100	4 AWG	2 AWG
125	2 AWG	1/0 AWG
150	1 AWG	2/0 AWG
200	2/0 AWG	4/0 AWG
225	3/0 AWG	250 KCMil
400	400 KCMil	600 KCMil

*Service over 400 amp require load calculations and engineering.

- The serving utilities (i.e. Xcel, CORE, and United Power) will not provide meter housings for residential use. Meter housings used must comply with the local energy supplier's requirements.

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- Xcel Energy requires a 200-ampere lever bypass type.
- If you are having to install a meter housing remote from the structure (as on a pole most likely with CORE and United Power) a disconnect will be required, and four (4) conductors shall be ran to the structure with an additional disconnect at the nearest point of entry into the building. [250.32(B)(1)].
- If a ground rod is used at the pole for your Grounding Electrode Conductor connection, a supplemental rod is required to be installed a minimum of 6' distance from the first rod. [250.53(A)(2) & (3)].
    - Antioxidant compound is required on all aluminum conductors.
    - Underground conductors must be suitable for direct burial. [310.10(E)]
- The service equipment shall be grounded in accordance with Article 250 of the NEC, which in general states that the grounded (neutral) conductor shall be bonded to the service entrance enclosure and the Grounding Electrode System defined in 250.28, 250.50, 250.52, 250.53.
    - For new construction: A concrete encased electrode (CEGE aka 'UFER') is required and needs to be inspected prior to placement of the concrete. [250.52(A)(3)] The electrode shall be at an accessible location in the garage. [Jefferson County Supplement]
- Location and Clearances **(Includes new service installation or replacement or upgrade)**
    - The main service equipment panel shall be mounted either outside or inside the dwelling as near as possible to the point of entrance of the service conductors to the building. [230.70(A)(1)]
    - Emergency Disconnect shall be installed in a readily accessible outdoor location on or within sight of the dwelling unit [230.85]
    - All service equipment and electrical panels shall have a clear area 30" wide or the width the equipment whichever is greater and 36" deep in front of the service.
    - The area in front of the service equipment must allow for the opening of doors to a minimum of 90 degrees. [110.26(A)]
        - This clear area must extend from floor to ceiling with no intrusions from other disciplines or obstructions.
    - **Electrical panels are not allowed in clothes closets, bathrooms, or over stairs. [**240.24(A), (D), (E), and (F)]
    - Service panels or sub panels shall not be installed in walls separating the garage from the dwelling unit (with some exceptions, consult your building inspector).

- **Service Grounding Requirements**
    - A surge protection device (SPD) listed Type I or II is required for services.
    - At the service equipment the grounded (neutral), grounding electrode conductors (i.e. water pipe, UFER, ground rods, etc.) and equipment grounding conductors are bonded (connected) together.
    - In subpanels [250.24(A)] (electrical panels remote from the main service panel and meter), the grounded (neutral) is isolated (separated) from ground and equipment grounding conductors. [250.24 (B)]
    - Grounding electrode conductors must be sized in accordance with Table 250.66
- NEC Requires a concrete-encased grounding electrode (CEGE/UFER) for all new installations and must be installed with foundation work.
    - Concrete isolated by foam forms, insulation, plastic sheeting, etc. is not considered to be in direct contact with earth.
    - CEGE's must be encased by minimum 2" of concrete, located horizontally near the bottom or vertically and within a portion of the foundation or footing that is in direct contact with the earth.
    - Requires minimum 20' minimum length, #4 (1/2") bare, zinc galvanized, or other electrically conductive coated steel reinforcing rods **OR** 20' bare copper conductor minimum 4 AWG

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ROUGH-IN INSPECTION:

- At the time you call for your rough-in inspection, you should have all wire pulled, stapled properly, and all splices made up and ready to accept devices and fixtures.
    - **Do not** install any devices or fixtures or cover any wiring with insulation or wall covering, (i.e. drywall, paneling) until inspected and approved.

TEMPORARY BUILDING SERVICE:

- Temporary building service meters shall be permitted and inspected, are only valid for sixty (60) days from date of issue and are for construction purposes only.
    - To obtain a temporary building service meter, the rough electrical inspections shall have been made and approved, the service shall be 100% complete and a GFCI receptacle on site, NOT IN the refrigerator space.
    - Additional "**allowable options" (**allowed but not required) for temporary building service are:
        - Heat Source (i.e. furnace, boiler, electric heat, etc.) **NOTE:** all appropriate heating equipment shall be installed per manufacturer's installation requirements. Appropriate venting for heating appliances shall be installed and any unused openings capped off properly. Thermostats shall be installed and operable.
        - A 30amp, 240volt GFCI protected receptacle installed at the dryer receptacle outlet location, (if needed for other trades/installers).
        - Well pump (to provide water).
        - These options must be installed prior to building service inspection or recall an inspection for these options when installed.
        - The only breakers to be terminated in the panel are the breakers for the mandatory GFCI (120volt) receptacle and allowable options.
- **If this meter is used for any purpose other than construction of if the building is occupied the inspector will have the meter removed without prior notice.**

FINAL INSPECTION:

- The electrical installation shall be complete at the time of request.
- The "temporary building service"/permanent power meter is set, service equipment complete and labeled properly.
- All wiring shall be free from short circuits, ground faults, and open circuits.
- All light fixtures are required to be complete (i.e. Lensed, glass, trims, and lamps installed)
- All 120volt circuits shall have power, unless blanked off for future use.

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