

PIKES PEAK REGIONAL BUILDING DEPARTMENT

Guidelines for Wiring Single Family Dwelling Units

Wiring must comply with the 2005 National Electrical Code (NEC), a code that is neither intended as a design specification nor instruction manual for untrained individuals. Its purpose is the practical safeguarding of persons and properties from hazards arising from the use of electricity. This handout is an overview of the NEC requirements for single family dwellings. The information does not cover requirements for every installation; it is to be used along with the NEC book. Refer also to RBD's Electrical handouts for Inspections, Basement Finish, Permanent Set, Service Meter & Panel, Temporary Set.

Inspections

Review the following information to understand what work needs to be completed before requesting inspections.

ROUGH INSPECTION — All wire must be pulled, stapled properly, and all splices made and ready to accept devices and fixtures. Do not install any devices or fixtures or cover any wiring with insulation or wall covering, such as drywall or paneling, prior to the rough-in inspection. Requirements of the equipment grounding conductor makeup must be completed.

FINAL INSPECTION — The electrical insulation must be complete when you request the final inspection. All devices and fixtures must be installed and service equipment complete and labeled properly. All wiring must be free from short circuits, ground faults and open circuits. All light fixtures and light switches must be grounded. All kitchen cabinets must be installed.

Service

The service equipment must be large enough to supply the connected load which is calculated using NEC Article 220. The most common sizes of residential service equipment are 100, 110, 125, 150 and 200 amperes. The minimum wire size for service entrance conductors are listed below. The service equipment must be grounded in accordance with NEC Article 250. The neutral must be bonded to the service enclosure and the grounding electrode system defined in NEC Article 250-50.

The main service panel must be mounted either outside or inside the dwelling as near as possible to the point of entrance of the service conductors to the structure.

All service equipment and electrical panels must have a clear area of 30 inches wide and 36 inches deep in front of the equipment. This clear area must extend from the floor to ceiling with no intrusions from other equipment, cabinets, counters, pipes, appliances, etc. Service equipment/panels are NOT allowed in clothes closets or bathrooms.

CONDUCTOR TYPES & SIZES (RH—RHH—THHW—THW—THWN—THHN—XHHW —USE)		
Copper AWG	Aluminum & Copper-Clad AL AWG	Service Rating in Amps
4	2	100
3	1	110
2	1/0	125
1	2/0	150
1/0	3/0	175
2/0	4/0	200
3/0	250 kcmil	225
4/0	300 kcmil	250
250 knmil	350 kcmil	300
350 knmil	500 kcmil	350
400 knmil	600 kcmil	400

Guidelines for wiring single family dwelling units

Grounding requirements

The service equipment must be grounded to comply with the provisions of Article 250 of the NEC, stating that the neutral must be bonded to the service enclosure and the grounding electrode system as defined in Article 250.50 of the NEC.

250.50 Grounding Electrode System. All grounding electrodes as described in 250.529(A)(1) - (6) 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) plate electrodes.

NOTE: The 2005 NEC now requires a concrete-encased electrode to be installed on all new installations, and must be installed when the footings are installed.

250.52(A)(3) Concrete-Encased Electrode. An electrode encased by a minimum of 2 inches of concrete located within and near the bottom of the 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 1/2 inch in diameter, or consisting of at least 20 feet of bare copper conductor not smaller than 4 AWG. Reinforcing bars are permitted to be bonded together by the usual tie wires or other effective means. *(Please refer to RBD's Eufer Grounding handout.)*

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

Branch circuit wiring

- NM cable (Romex) is universally used in residential dwellings. NM cable must have a 90° conductor insulation rating designated by a "B" on the cable sheath.
- NM-B #12 and #14 are used for lighting and general purpose receptacle circuits;
- #10/2 w/ground is commonly used for electric water heaters;
- #10/3 w/ground is used for electric dryers;
- #8/3 and #6/3 w/ground is used for ranges and wall mounted ovens;
- Type SER cable with an insulated neutral is permitted for electric ranges, wall ovens and dryers.

Do not mix wire sizes on the same branch circuit. If you begin a circuit with #12, the same size wire must be used throughout.

INSTALLATION OF NM CABLE (ROMEX) — NM cable must be stapled within 12 inches of metal boxes, 8 inches of plastic boxes, and every 4 1/2 feet thereafter. Proper connectors must be used where NM cable enters metal cabinets, boxes or panel boards.

Only two Romex are allowed in one Romex connection.

When NM cable is installed parallel to framing members or in bored holes, it must be located at least 1 1/4 inches from the nearest edge of the framing member to avoid nails or screws from penetrating the cables. If this distance can't be maintained, the cable must be protected by a steel plate or sleeve at least 1/16 inch thick. NEC 300-4(A).

Cable or raceway-type wiring methods installed in a groove to be covered by wallboard, siding, paneling, carpeting or similar finish must be protected. The cable or wiring must be shielded with a 1/16 inch deep steel plate, sleeve or equivalent OR recessed 1 1/4 inch deep for the full length of the groove in which the cable or raceway is installed.

Exception: Raceways explained in articles 342, 344, 352, and 358. NEC 300-4(E).

CEILING MOUNTED PADDLE FANS — Ceiling mounted paddle fan outlet boxes or outlet box systems used as the sole support must be listed and specified for this use by the manufacturer, and limited to support fans weighing 70 pounds or less. Boxes used to support fans weighing more than 35 pounds must be marked to show the maximum support weight. NEC 314.27(D).

Cables must be protected by over-current devices (circuit breakers) that do not exceed their rated amp capacity. Amp capacities for cable types are:

COPPER NM CABLE	SE & SER ALUMINUM CABLE
15 amperes for #14	40 amperes for #8
20 amperes for #12	50 amperes for #6
30 amperes for #10	
40 amperes for #8	
50 amperes for #6	

Guidelines for wiring single family dwelling units

Required branch circuits

BEDROOMS & ARC FAULT PROTECTION — All 120-volt, single phase, 15- and 20-ampere branch circuits supplying outlets (lights, receptacles, smoke detectors) installed in dwelling unit bedrooms must be protected by a listed arc-fault circuit interrupter, combination type to protect branch circuit. Branch/feeder AFCI's are permitted for use until January 1, 2008. NEC 210.12(B).

GENERAL LIGHTING BRANCH CIRCUITS — Circuits must be computed on a three watts per foot basis. Up to 600 square feet of living area may be wired 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 described in the following paragraphs of this section.

BATHROOM — A minimum of one 20 amp circuit for bathroom receptacle outlets must be supplied, and not be used for other outlets. Exception: Where the 20 ampere circuit supplies a single bathroom, outlets for other equipment within the same bathroom may be supplied in compliance with NEC 210.23(A). This circuit CANNOT be used for a whirlpool or hot tub.

CENTRAL HEATING — Central heating equipment must be supplied by an individual branch circuit.

SMALL APPLIANCE BRANCH CIRCUITS — A minimum of two 20 ampere branch circuits are required to feed receptacle outlets for small appliance loads, including refrigeration equipment in the kitchen, pantry, breakfast room, dining room. These circuits, whether two or more are used, CANNOT feed anything other than the receptacles in these areas. Lighting outlets and built-in appliances, such as garbage disposals, dishwashers and trash compactors, are NOT permitted on these circuits. Kitchen counter top receptacles must be supplied by a least two small appliance branch circuits. **Exception:** The receptacle outlet for refrigeration equipment is permitted to be supplied from an individual branch circuit rated 15 amperes or greater.

LAUNDRY BRANCH CIRCUITS — A single 20 amp branch circuit must be provided for the laundry. This circuit is limited to receptacles within the laundry room. No other outlets are permitted in this circuit.

Receptacle outlets

BASEMENT — At least one receptacle must be installed in each unfinished basement. This receptacle is in addition to any that may be installed for laundry purposes or other specific purpose.

BATHROOMS — At least one outlet will be installed within 36 inches of the outside edge of each basin. The receptacle outlet will be located on a wall that is adjacent to the basin.

FLOOR RECEPTACLES — Receptacles installed in the floor must use a box-receptacle combination designed specifically for that purpose. If installed in the floor within 18 inches of the wall, it may be used in place of wall mounted receptacles.

GARAGES — At least one outlet must be installed in each attached garage, and one in each detached garage with electric power.

HALLWAY — A receptacle outlet is required in any dwelling unit hallway that is 10 feet or more in length.

HEATING, AC, REFRIGERATION EQUIPMENT — A 125 volt, 15- or 20-ampere receptacle outlet must be installed at an accessible location for servicing of this equipment. The outlet must be located on the same level and within 25 feet of equipment, including those mounted on roof. Exception: Evaporative coolers.

KITCHENS AND DINING AREAS — a receptacle outlet must be installed at each counter space 12 inches or wider. Receptacles will be installed so that no point along the wall line is more than 24 inches measured horizontally from a receptacle outlet in that space. Peninsular bars and islands 12 inches wide or greater must have a minimum of one receptacle.

OUTDOOR OUTLETS — At least two outlets must be installed outdoors, one in front and one in back of the dwelling, and be accessible at grade level. When installed in wet locations, a weatherproof enclosure is required whether or not the attachment plug cap is inserted.

ROOMS — In every kitchen, family room, dining room, living room, parlor, library, den, sun room, bedroom, recreation room or similar room of a dwelling unit, receptacle outlets must be installed so that no point along the floor line in any wall space is more than six feet horizontally, from an outlet in that 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, will be included in the six-foot measurement. No outlet may be installed over an electric baseboard heater.

SPA OR HOT TUB AREA — At least one 15 or 20 ampere, 125 volt GFCI protected receptacle must be installed at a spa or hot tub location — not closer than 5 feet from the inside wall of the unit and not more than 10 feet away for an indoor installation; a minimum of 10 feet away for an outdoor installation. Light fixtures, outlets and ceiling fans over spas and hot tubs must be a minimum of 7 feet 6 inches above the maximum water level. Outdoor spas and hot tubs have the same requirements as swimming pools.

Guidelines for wiring single family dwelling units

Lighting outlets

OUTLETS REQUIRED IN COMMON LOCATIONS— At least one wall switch-controlled lighting outlet must be installed in every habitable room: bathrooms, hallways, stairways, attached garages, detached garages with electric power, and outdoor entrances or exits. The lighting outlet for interior stairways will have a wall switch at each floor level where the difference between floor levels is six steps or more.

STORAGE AND EQUIPMENT AREAS — 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 that requires servicing. The switch must be located at the point of entry to the area and the lighting outlet located at or near the equipment that requires servicing.

Ground fault protection

Receptacles that must be protected by a ground fault interrupter include:

- Bathroom receptacles
- All outdoor receptacles
- Kitchen receptacles that serve counter top surfaces
- Receptacles within 6 feet of a wet bar, laundry or utility sink
- Hydromassage bath tubs
- Spas and hot tubs and associated components

- Garage and accessory buildings with a floor located at or below grade level, not intended as habitable rooms and limited to storage or work areas. (*GFCI protection is not required for receptacles that are not readily accessible such as ceiling mounted receptacles or single receptacles in dedicated areas for appliances.*)

- All receptacles in an unfinished basement or crawl space at or below grade. Exceptions: Laundry receptacle, single receptacle on a dedicated circuit located and identified for specific use by a cord and plug connected appliance, and single receptacle serving permanently installed sump pump.

Required disconnecting means

Disconnects are required in sight of the following equipment:

- Electric hot water heaters
- Well pump controllers
- Central heating equipment (furnaces, boilers, etc.)
- Spas and hot tubs
- Hydromassage bathtubs
- Appliances

Conductor fill

Outlet and junction boxes must 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.

EXAMPLE: Two #12/2 with ground NM-B cables entering a box with one duplex receptacle require a box with a minimum volume of 15.75 cubic inches. Each #12 that enters the box needs 2.25 cubic inches with the exception of the grounding conductor that requires one 2.25 cubic inch for one or all. In addition, each strap containing one or more devices is counted as the equivalent of two conductors, $(2.25 \times 2 = 4.5)$.

Volume required per container

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

Equipment grounding conductors

All equipment grounding conductors must be connected together with 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 must be crimped using the tool recommended by the manufacturer. **NOTE:** All metal junction & outlet boxes must be grounded by attaching the equipment grounding conductor out of the NM cable to the metal box using an approved screw or grounding clip.

When circuit conductors are made up, six inches of free conductor measured from the front of the box must be left for use in makeup and for the attachment of devices.

Electric heat circuitry

Electric heat must 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.

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

(All circuits are figured at 240v.)

EXAMPLE: When installing a baseboard heater that is rated 250 watts per linear foot, you could install 15 feet on a 20 amp, 240 volt circuit, $(250w \times 15 = 3,750 \text{ watts})$.