Code ✓Check® Electrical 6th Edition

Based on the 2011 NEC® and the 2009 IRC®

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Code Check Electrical 6th Edition is a field guide to common code issues in residential electrical installations. It is based on the ***2011 National Electrical Code***–the most widely used electrical code in the United States–and the ***2009 International Residential Code.*** Before beginning any electrical project, check with your local building department. In addition to a model code, energy codes and special rules from utility companies could also apply.

Each code line in ***Code Check Electrical*** references the two codes named above. Many building jurisdictions use older versions of the codes. If you are in an area that still uses the 2008 NEC, look in the "**09 IRC**" column of code references to see if the item applies in your area and use the table on **p.61** to see changes that were made in the **2008 NEC**, **2009 IRC**, and **2011 NEC**.

When the IRC does not reference a particular rule, the NEC might apply, even where the IRC is the adopted code. The IRC states that items not specifically mentioned in it must comply with the NEC. This applies to issues such as old wiring, outside feeders, and photovoltaics, which are not covered in the IRC.

Thanks to Hamid Naderi, International Code Council, for his invaluable editorial input.

For information on electrical fundamentals and theory, visit:

http://www.codecheck.com/cc/OhmsLaw.html.

HOW TO USE CODE CHECK ELECTRICAL

~~Every IRC code citation, and every figure or table reference, is a hyperlink.~~ Clicking on the figure or table reference will take you to the page of the book where it is located. Clicking the "restore previous view" button above takes you back to the page you had been viewing. If you have an internet connection, clicking on an IRC code citation opens a browser window to the text of the code. For copyright reasons, that cannot be done with the NEC citations.

Each text line ends with two code citations. The code numbers on the left, with straight brackets, refer to the 2009 IRC. The code numbers on the right, in braces, refer to the 2011 NEC. As in the following example from **p.9**:

☐ Max 6 disconnects to shut off power_____ [3601.7] {230.71}

This line states that there can be no more than 6 disconnects to shut off the power, and the rule is found in 3601.7 of the IRC and 230.71 of the NEC.

An "EXC" at the end of a line means that an exception–or exceptions–to the rule will follow in the next line, as on **p.17**:

☐ Size per service conductor size **T5** EXC _____ [3603.4] {250.66}
• 6 AWG Cu largest size GEC needed if ending at rod [T3603.1] {250.66A}

*This states that the grounding electrode conductor size is based on the size of the service conductors, in accordance with **Table 5**, except that the portion of the grounding electrode conductor that solely serves a ground rod need never be larger than 6 AWG.*

Significant code changes are highlighted by a code citation in a different color. The superscript after the code citation refers to the table on **p.61**. The following example is from **p.29:**

☐ GFCIs req'd to be in readily accessible locations _____[n/a] {210.8A}[19]

*GFCI devices must be located in an area where they remain readily accessible. The rule is not in the IRC. In the NEC it is a change in the 2011 code, summarized as change #19 in Table 23 on **p.61**.*

Text lines ending in OR mean that an alternative rule follows in the next line, as on **p.32:**

☐ Separate 20A circuit for bath receptacles only OR_____ [3703.4] {210.11C3}
• Dedicated 20A circuit to each bathroom _____[3703.4X] {210.11C3X}

A separate 20-amp circuit must be supplied for no other purpose than the bathroom receptacles. Alternatively, each bathroom can be supplied with its own 20-amp circuit, and then other outlets in that bathroom (such as lights) could be on the circuit.

An "n/a" in a code line means the rule is not applicable to that particular code.

ABBREVIATIONS

A = amp(s), amperage, amps, such as a 15A breaker
AC = air conditioning
AC = alternating current
AC = armored cable, a.k.a. "BX"
AFCI = arc-fault circuit interrupter
AHJ = Authority Having Jurisdiction
Al = aluminum
AMI = in accordance with manufacturer's instructions
AWG = American Wire Gauge
CATV = cable television
CO = carbon onoxide
cu. = cubic, as in cu. in.
Cu = copper
DC = direct current
EGC = equipment grounding conductor
EMT = electrical metallic tubing
ENT = electrical nonmetallic tubing, a.k.a. "Smurf tubing"

ABBREVIATIONS (CONTINUED)

EV = electric vehicle
EXC = exception(s)
FMC = flexible metal conduit, a.k.a. "Greenfield"
ft. = foot, feet
GEC = grounding electrode conductor
GES = grounding electrode system
GFCI = ground-fault circuit interrupter
GFPE = ground-fault protection of equipment
hp = horsepower
IMC = intermediate metal conduit
in. = inch(es)
IRC = International Residential Code
kcmil = 1,000 circular mil units (conductor size)
L&L = listed & labeled, listing & labeling
lb. = pound(s)
LFMC = liquidtight flexible metal conduit, a.k.a. "Sealtight"
LFNMC = liquidtight flexible nonmetallic conduit
manu = manufacturer(s)
max = maximum
MC = metal-clad cable
min = minimum
NEC = National Electrical Code
NFPA = National Fire Protection Association
NM = nonmetallic-sheathed (cable)
OCPD = overcurrent protection device (breaker or fuse)
PV = photovoltaic
PVC = rigid polyvinyl chloride conduit
req = require, requiring, requirement
req'd = required
req's = requires
RMC = rigid metal conduit
SCCR = short circuit current rating
SE = service entrance cable
SFD = single-family dwelling
sq. = square, as in sq. in.
temp = temperature
UF = underground feeder cable
USE = underground service entrance cable
TR = tamper-resistant
V = volt(s), such as a 120V circuit
VA = volt-ampere(s), units of apparent power
W = watt(s), units of true (useful) power
WR = weather-resistant

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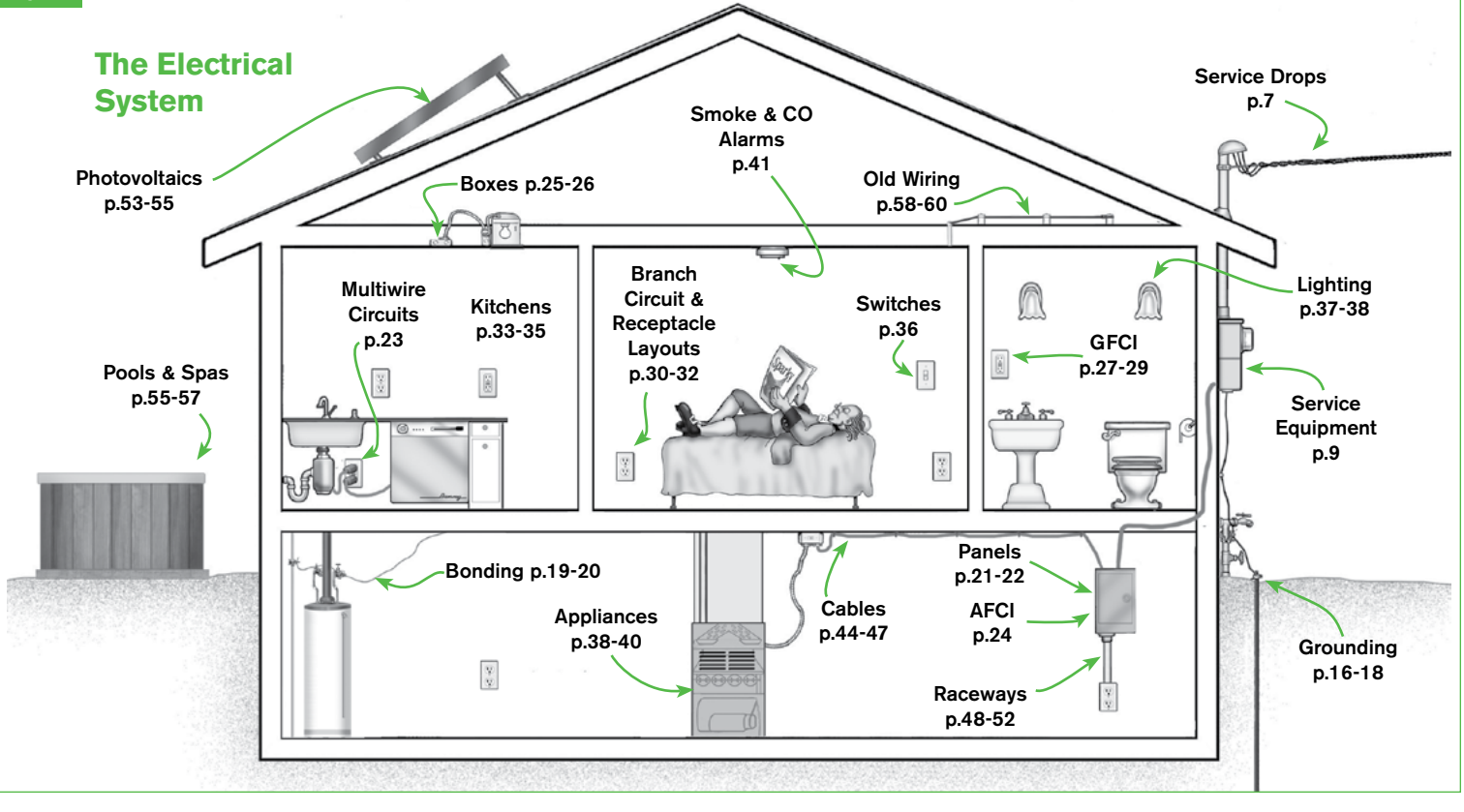
FIG. 1



GLOSSARY OF ELECTRICAL TERMS

Accessible, as applied to wiring methods: Not permanently concealed or enclosed by building construction.

Accessible, as applied to equipment: Capable of being removed or exposed without damaging the building finish or structure. A piece of equipment can be considered accessible even if tools must be used or other equipment must be removed to gain access to it.

Accessible, readily: Capable of being reached quickly for operation or inspection without the necessity of using tools to remove covers, resorting to ladders, or removing other obstacles.

Alternating current (AC): Current that flows in one direction and then in the other in regular cycles, referred to as frequency or Hertz.

Apparent power: See "*Power*."

Approved: Acceptable to the authority having jurisdiction (AHJ). The AHJ will usually approve materials that are listed and labeled.

Arc-fault: An electric current propagated through air.

- **Arc-Fault Circuit Interrupter (AFCI):** A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.
- **AFCI, branch/feeder type:** "First generation" AFCI devices capable of interrupting parallel arcing faults. They do not meet the present code standard.
- **AFCI, combination type:** An AFCI meeting the standard for interrupting both series and parallel arcs.

Authority Having Jurisdiction (AHJ): The building official or persons authorized to act on his or her behalf.

Bonded, bonding: Connected to establish continuity and conductivity.

Branch circuit: The circuit conductors between the final overcurrent protection device (OCPD) (breaker or fuse) protecting the circuit and the outlet or outlets.

- **Branch circuit, general purpose:** Branch circuit that supplies 2 or more receptacles or outlets for lighting and appliances.
- **Branch circuit, individual:** Branch circuit supplying only 1 piece of equipment.
- **Branch circuit, multiwire, residential:** Branch circuit consisting of 2 hot conductors having 240V potential between them and a grounded neutral having 120V potential to each hot conductor F17.
- **Branch circuit, small appliance:** Branch circuit supplying portable household appliances in kitchens and related rooms and that has no permanently installed equipment connected to it (see **p.33** for exceptions).

Clothes closet: A non-habitable room or space intended primarily for storage of garments & apparel F37.

Controller: A device to directly open and close power to a load.

Derating: A reduction in the allowable ampacity of conductors because of ambient temperatures > 86°F, or more than 3 current-carrying conductors in the same raceway, or for cables without spacing between them.

Device: A piece of equipment that carries or controls electrical energy as its primary function, such as a switch, receptacle, or circuit breaker.

Equipment: A general term including materials, fittings, devices, appliances, luminaires (fixtures), apparatus, machinery, and the like used as a part of, or in connection with, an electrical installation.

Equipment grounding conductor (EGC): A wire or conductive path that limits voltage on metal surfaces and provides a path for fault currents F16.

Feeders: Conductors supplying panelboards other than service panels.

Flexibility after installation: Anticipated movement after initial installation, such as that caused by motor vibration or equipment repositioning.

Gooseneck: A curve at the top of a service entrance cable designed to prevent water from entering the open end of the cable.

Ground: The earth.

Grounded conductor: A current-carrying conductor that is intentionally connected to earth (a neutral).

Grounding electrode conductor (GEC): A conductor used to connect the service neutral or the equipment to a grounding electrode or to a point on the grounding electrode system F6.

Ground fault: An unintentional connection of a current-carrying conductor to equipment, earth, or conductors that are not normally intended to carry current.

- **Ground-Fault Circuit Interrupter (GFCI):** A device to protect against shock hazards by interrupting current when an imbalance of 6 milliamps or more is detected.
- **Ground-Fault Protected Equipment (GFPE):** A device to protect equipment from ground faults and allowing higher levels of leakage current than a GFCI.

Hertz: A measure of the frequency of AC. In North America, the standard frequency is 60 Hertz.

Individual branch circuit: See "*Branch circuit, individual.*"

In sight: See "*Within sight.*"

Interrupting rating: The highest current a breaker or fuse can interrupt without sustaining damage.

Lighting outlet: An outlet intended for the direct connection of a lampholder or a luminaire.

Load: The demand on an electrical circuit measured in amps or watts.

Location, damp: An area protected from the weather, yet subject to moderate degrees of moisture, such as a covered porch.

Location, dry: A location not normally subject to dampness or wetness.

Location, wet: All areas subject to direct saturation with water, and all conduits in wet outdoor locations or underground or in concrete or masonry in earth contact.

Luminaire (formerly lighting fixture): A complete lighting unit including parts to connect it to the power supply, and possibly parts to protect or distribute the light source. A lampholder, such as a porcelain socket, is not itself a luminaire.

Neutral conductor: The conductor connected to the neutral point of a system that is intended to carry current under normal conditions **F17.**

Open conductors: Individual conductors not contained within a raceway or cable sheathing, such as a typical service drop.

Outlet: The point on a wiring system at which current is taken to supply equipment. A receptacle or a box for a lighting fixture is an outlet; a switch is not an outlet.

Overcurrent: Any current in excess of the rating of equipment or conductor insulation. Overcurrents are produced by overloads, ground faults, or short circuits.

Overfusing: A fuse or breaker that has an overload rating greater than allowed for the conductor it is protecting.

Overload: Equipment drawing current in excess of the equipment or conductor rating and in such a manner that damage would occur if it continued for a sufficient length of time. Short circuits and ground faults are not overloads.

Panelboard: The "guts" of an electrical panel; the assembly of bus bars, terminal bars, etc., designed to be placed in a "cabinet." What is commonly called an electrical panel or load center is, by NEC terms, a panelboard mounted in a cabinet **F16.**

Power: There are 2 designations for AC electrical power. Apparent power (input) is expressed in V × A. True power (useful output) is expressed in watts.

Service: The conductors and equipment providing a connection to the utility **F2**.

Service drop: The overhead conductors supplied by the utility **F2**.

Service entrance conductors: The conductors from the service point to the service disconnect.

Service equipment: The equipment at which the power conductors entering the building can be switched off to disconnect the premises' wiring from the utility power source. A meter can be a part of or separate from the service equipment.

Service lateral: Underground service entrance conductors.

Service point: The connection or splice point at which the service drop and service entrance meet–it is the handoff between the utility and the customer.

Short circuit: A direct connection of current-carrying conductors without the interposition of a load, resulting in high levels of current.

Short Circuit Current Rating (SCCR): The amount of current that panelboards and switchboards must be able to carry during a short circuit condition without sustaining damage. See *"Interrupting rating."*

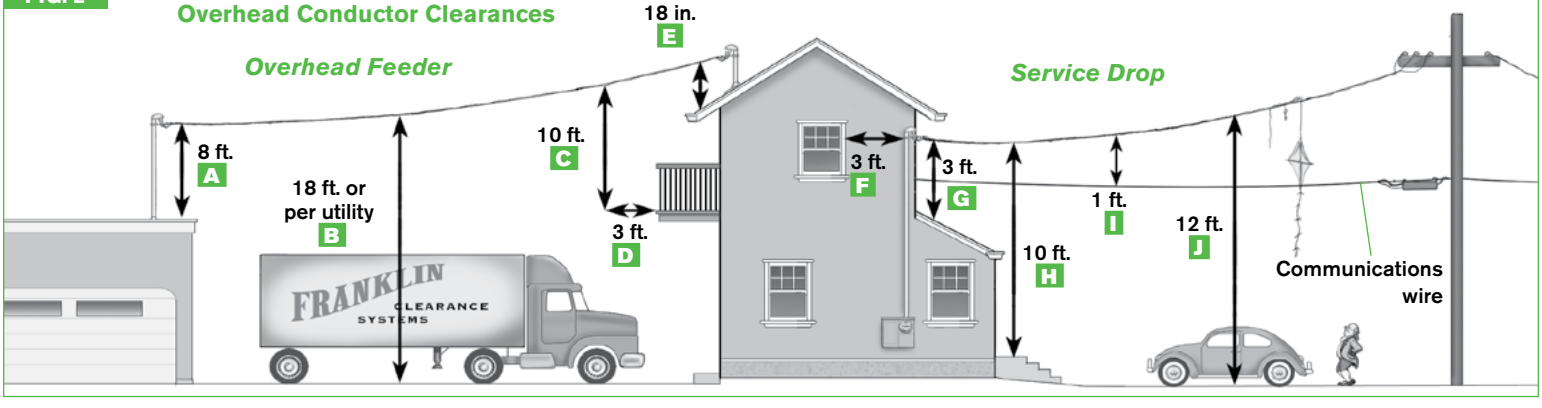
Snap switch: A typical wall switch, including 3-way and 4-way switches.

Ufer: a concrete-encased grounding electrode, named after the developer of the system, Herbert Ufer **F6**.

Unit switch: A switch that is an integral part of an appliance.

Within sight (also called *"in sight"*): Visible, unobstructed, and not more than 50 ft. away.

FIG. 2



OVERHEAD SERVICE DROP CLEARANCES

Service drop conductors typically have no outer jacket for physical protection and no overload protection at their source. They are protected by isolation and proper clearances. The codes specify minimum clearances, and the serving utility may have different rules that override the code. Check with your local jurisdiction to determine any variations from the standard clearances below.

Vertical above Roof F2	09 IRC	11 NEC
☐ <4-in-12 slope: min 8 ft. A EXC	[3604.2.1]	{230.24A}
• 3 ft. OK if roof area guarded or isolated	[n/a]	{230.24AX5}[1]
☐ ≥ 4-in-12 slope: min 3 ft. G EXC	[3604.2.1X2]	{230.24AX2}
• 18 in. OK for ≤4 ft. over eaves E	[3604.2.1X3]	{230.24AX3}
☐ Maintain req'd distance above roof for 3 ft. past edge EXC	[3604.2.1]	{230.24A}
• Edge clearance above roof is not req'd when attached to side of building	[3604.2.1X4]	{230.24AX4}

Vertical above Grade F2	09 IRC	11 NEC
☐ 10 ft. above final grade to lowest point of drip loop	[3604.2.2]	{230.24B1}
☐ Area accessible only to pedestrians: 10 ft. H	[3604.2.2]	{230.24B1}
☐ General above grade & driveways: 12 ft. J	[3604.2.2]	{230.24B2}
☐ Above roads or parking areas subject to truck traffic: 18 ft. B	[3604.2.2]	{230.24B4}
☐ Any direction from swimming pool water: 22½ ft.	[4203.5]	{680.8A}

Openings & Communication Wires F2	09 IRC	11 NEC
☐ Vertical above decks & balconies: 10 ft. C	[n/a]	{230.9B}
☐ From side of area above decks & balconies: 3 ft. D	[3604.1]	{230.9A}
☐ Below or to sides of openable window: 3 ft. F	[3604.1]	{230.9A}
☐ Communications wire ≥ 12 in. to parallel power wires I	[n/a]	{800.44A4}

The clearances from windows & doors apply to open conductors & not to conductors contained inside a raceway or a cable with an overall outer jacket. The codes do not have a requirement for min. clearance of open conductors above a window. Check to see if your local utility has a requirement.

SERVICE ENTRANCE CONDUCTORS

The connection between the service drop or lateral and the permanently installed building wiring is typically considered the "service point"–the handoff from the utility to the customer. From that point to the service equipment, the conductors are referred to as service entrance conductors. Though the utility does not have exclusive control of these conductors, they may still have jurisdiction over them, including the size of conduits and the placement of metering equipment.

General	09 IRC	11 NEC
☐ Wire size for SFD per T10	[T3603.1]	{T310.15B6}
☐ Min wire size for SFD 4 AWG Cu or 2 AWG Al T10	[T3603.1]	{T310.15B6}
☐ Conductors & cables exposed to sunlight L&L as sunlight-resistant or covered with material L&L as sunlight-resistant	[3605.6]	{310.8D}
☐ Identify (white marking or tape) neutral at both ends	[3407.1]	{200.6B}
☐ Service heads/goosenecks above attachment point EXC	[3605.9.3]	{230.54C}
• Attachment within 24 in. OK when necessary	[3605.9.3X}	{230.54CX}
☐ No branch circuits or feeders in same raceway with service conductors	[3601.4}	{230.7}
☐ Form drip loop in conductors	[3605.9.5]	{230.54F}
☐ Individual open conductor insulating supports min 2 in. from building surfaces	[n/a]	{230.51C}

Service Entrance (SE) Cables	09 IRC	11 NEC
☐ Protect SE cables subject to damage with metal conduit, PVC-80, EMT, or other approved means F58,59,63	[3605.5]	{230.50B}
☐ Secure SE cable every 30 in. & 12 in. from terminations	[3605.7]	{230.51A}
☐ Raintight service head or taped gooseneck req'd	[3605.9.2]	{230.54B}
☐ Seal SE cable to prevent water entry to box	[3605.9.6]	{230.54G}

Service Riser	09 IRC	11 NEC
☐ Wiring method listed for electrical (no plumbing pipe)	[3605.2]	{230.43}
☐ Suitable for wet location if exposed to weather	[3605.8]	{230.53}
☐ Overhead raceway req's raintight service head	[3605.9.1]	{230.54A}
☐ Brace riser to utility or local specifications	[3604.5]	{230.28}
☐ Only power conductors on service risers–no CATV	[3604.5]	{230.28}
☐ Size raceway to max 40% fill T17–T22	[3904.6]	{9-T1&T4}
☐ Size raceway per utility	[utility]	{utility}

COMMON UTILITY COMPLAINTS

Aside from code issues, utility company rules and standards must be followed. Most utilities publish their gas and electrical service requirements or post them online. The following items are not in the codes, and you should consult with your local utility to comply with their rules on these issues.

Meter Base(s)

- ☐ Too close to gas meter
- ☐ Height incorrect
- ☐ Barrier post (bollard) needed to protect meter from vehicles on driveway
- ☐ Not readily accessible to meter readers

Service Entrance Conductors

- ☐ Insufficient conductor length at service head
- ☐ Insufficient clearance to communication lines
- ☐ Insufficient clearance above windows
- ☐ Height above standing surface (roof deck) too low
- ☐ Trees under service drop
- ☐ Customer performing own cutover from old service to new

SERVICE PANELS

The term "service equipment" refers to the switches, circuit breakers, or fuses that disconnect power from the utility at the customer's end of the service conductors. A meter is not considered service equipment, though it is sometimes in the same enclosure as the service equipment. As with all electrical equipment that might req access for maintenance, examination, or repair, sufficient working space must be maintained around service equipment.

General	09 IRC	11 NEC
☐ Enclosure L&L as suitable for service equipment	[3601.6.1]	{230.66}
☐ Max 6 disconnects to shut off power	[3601.7]	{230.71}
☐ Service disconnects labeled as such	[3601.6.1]	{230.70B}
☐ In multiple-occupancy building, each occupant must have ready access to disconnect EXC	[3601.6.2]	{230.72C}
• OK for management to have only access to service disconnect supplying > 1 occupancy	[n/a]	{230.72CX}
☐ Max height of breaker 6 ft. 7 in.	[4001.6]	{240.24A}
☐ Provide working space F3	[3405.2]	{110.26}

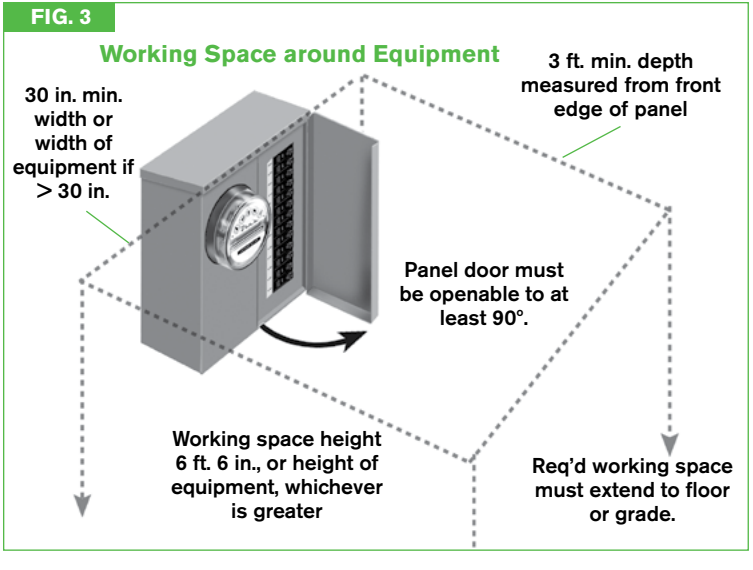
WORKING SPACE

Working space around equipment is essential for worker safety. These requirements apply to any electrical equipment that might req examination, adjustment, servicing, or maintenance while energized. The spaces around electrical equipment should not be used for storage.

General F3	09 IRC	11 NEC
☐ Front working clearance min 36 in. deep	[3405.2]	{110.26A1}
☐ Distance measured from face of enclosure or live parts	[3405.2]	{110.26A1}
☐ Work space extends to floor EXC	[3405.2]	{110.26A3}
• Related equipment may extend 6 in. beyond panel front	[3405.2]	{110.26A3}
☐ Clear width min 30 in. wide or width of equipment	[3405.2]	{110.26A2}

General (cont.) F3	09 IRC	11 NEC
☐ Panel need not be centered in space, hinged doors must be openable at least 90°	[3405.2]	{110.26A2}
☐ Working space not to be used for storage	[3405.4]	{110.26B}
☐ Illumination req'd for all indoor panels	[3405.6]	{110.26D}
☐ Min headroom for service & panels 6½ ft.	[3405.7]	{110.26A3}

FIG. 3

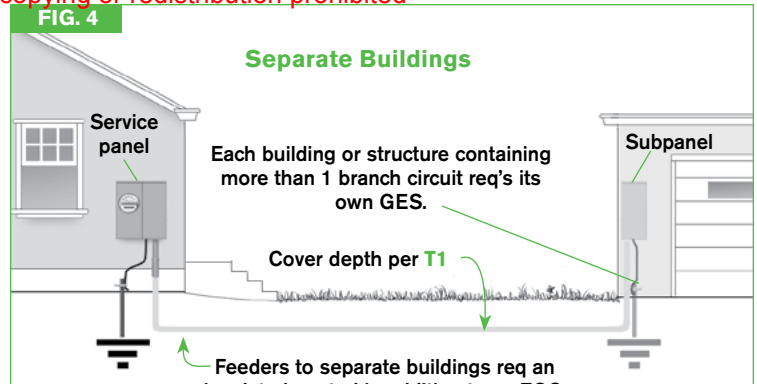


SEPARATE BUILDINGS

Care must be taken to avoid objectionable currents on the grounding paths between buildings supplied by a common service. Install separate insulated neutral conductors, rather than using the grounding conductors as neutrals. The IRC does not address outside feeders and separate buildings except for the rules on grounding.

Outside Feeders	11 NEC
☐ Trees may not support overhead conductors	{225.26}
☐ Overhead feeder height rules same as services **F2**	{225.18&19}
☐ Provide proper cover for buried cable or conduit **F5, T1**	{300.5}
☐ Each building or structure req's GES EXC **F4**	{250.32A}
• Building or structure with only 1 branch circuit with EGC	{250.32AX}
☐ Multiwire circuit considered 1 circuit for above rule	{250.32AX}
☐ Seal underground raceways where entering building	{225.27}[2]
☐ Max 1 feeder or branch circuit to each building	{225.30}
☐ Max 1 feeder or branch circuit back to original building	{225.30}[3]
☐ Disconnect req'd at each building **F4**	{225.31}
☐ Disconnect must be rated as service equipment EXC	{225.36}
• Garages or outbuildings snap switches or 3-ways OK	{225.36X}
☐ EGC (4-wire feeder) req'd between buildings EXC	{250.32B}
• Existing installations to separate buildings with no continuous metal paths, e.g., metal water pipe, etc., between 2 structures	{250.32BX}
☐ Do not bond neutral to EGC or enclosure in subpanel	{250.32B}

FIG. 4



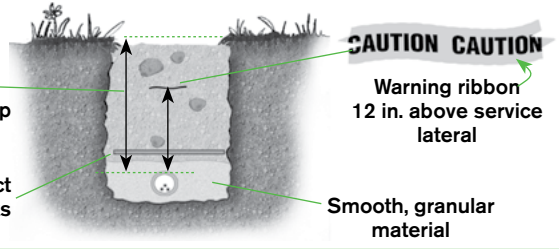
MULTI-METER SERVICES

Services to 2-family and multi-family dwellings might come to a multi-meter panel, or to a "hot gutter" with splices ahead of any overcurrent protection. See **p.29** for bonding requirements on such services

General	09 IRC	11 NEC
☐ Only 1 service per building	[3601.2]	{230.2}
☐ Provide each occupant access to service disconnect	[3601.6.2]	{230.72C}
☐ Bonding req'd at hot gutters **F11,12**	[3609.2]	{250.92A}
☐ Service disconnects grouped in 1 location	[3601.7]	{230.71A}
☐ Service conductors may not pass through interior of 1 building to another building	[3601.3]	{230.3}

FIG. 5

Conductors in Trench



TEMPORARY WIRING

Safety is the highest priority during construction, and GFCI protection is req'd for all 120V receptacles on construction sites. Some jurisdictions allow a limited number of temporary circuits from a service installation prior to the rough wiring stage (before weather protection). The IRC does not address temporary wiring.

General	11 NEC
☐ Allowed only during construction, repair, remodeling & similar	{590.3A}
☐ Service conductor clearances same as permanent F2	{590.4A}
☐ Support & brace pole to utility specifications	{utility}
☐ Provide overcurrent protection for branch circuits	{590.4C}
☐ No receptacles on branch circuits supplying temporary lighting	{590.4D}
☐ All multiwire circuits req handle ties	{590.4E}
☐ Lampholders req guards	{590.4F}
☐ Splices in NM cable or MC cable OK without splice box	{590.4G}
☐ Protect cords & cables from accidental damage	{590.4H}
☐ GFCI req'd on all 125V 15, 20 & 30A temporary receptacles EXC	{590.6A1}
• Listed GFCI cord-sets OK on existing permanent receptacles	{590.6A2}[4]

UNDERGROUND WIRING

Underground wiring methods include individual insulated conductors, cables rated for underground installation, and raceways. The most common method is PVC conduit. If there is a significant difference in elevation between the ends of an underground raceway, it may be necessary to install a pull-box for drainage near the downhill end.

General	09 IRC	11 NEC
☐ Burial depth must provide cover per T1, F5	[3803.1]	{300.5A}
☐ Warning ribbon in trench 12 in. above service laterals F5	[3803.2]	{300.5D3}
☐ Direct-buried cables or conductors must be protected by enclosures or raceways from req'd burial depth or 18 in. (whichever is less) to termination above grade or 8 ft. high (whichever is less) F52	[3803.3]	{300.5D1}
☐ Protect conductors & cables emerging from grade with RMC, IMC, PVC-80, or equivalent F52	[3803.3]	{300.5D4}
☐ OK to splice or tap direct-buried conductors without boxes with splicing means listed for the purpose	[3803.4]	{300.5E}
☐ Backfill smooth granular material–no rocks F5	[3803.5]	{300.5F}
☐ Boards or sleeves for protection where necessary F5	[3803.5]	{300.5F}
☐ Seal underground raceway entries (vapor protection)	[3803.6]	{300.5G}
☐ Bushing req'd between underground cables or individual conductors & protective conduit F52	[3803.7]	{300.5H}
☐ All conductors of circuit in same trench or raceway	[3803.8]	{300.5I}
☐ Allow provision for earth movement (settlement or frost) using "S" loops, flexible connections &/or expansion fittings	[3803.9]	{300.5J}

TABLE 1	MIN. COVER REQUIREMENTS IN TRENCH [T3803.1] & {300.5}				
Cover	UF Cable	Rigid Metal	PVC	GFCI ≤ 20A Circuit	≤ 30V
General	24 in.	6 in.	18 in.	12 in.	6 in.
2 in. concrete	18 in.	6 in.	12 in.	6 in.	6 in.
Under building	0[A]	0	0	n/a	n/a
4 in. slab, no vehicles	18 in.	4 in.	4 in.	6 in.	6 in.
Street	24 in.	24 in.	24 in.	24 in.	24 in.
Driveway	18 in.	18 in.	18 in.	12 in.	18 in.

A. MC cable identified for direct burial also OK in 2011 NEC.

SERVICE & FEEDER LOAD CALCULATIONS

The calculation methods in the codes take into account that not all of the possible electrical loads will be used at the same time. Each of the calculation methods allows the use of "demand factors." The "long form," shown below and in T2, is the most common calculation method. For information on multifamily load calculations, refer to the Code Check website at ***www.codecheck.com***.

Load Calculation Steps (Long Form) T2 — 11 NEC

1. Determine the sq. ft. area of the residence & multiply by 3W (exclude garage & covered patios) _____ {220.12}
2. Min of 2 small-appliance circuits at 1,500W each _____ {220.52A}
3. Each additional small appliance circuit at 1,500W _____ {220.52A}
4. Minimum 1 laundry circuit at 1,500W _____ {220.52B}
5. Enter total of appliance circuits & general lighting _____ {220.42}
6. First 3,000W counted at 100% (carries to right column) _____ {T220.42}

Load Calculation Steps (Long Form) (cont.) T2 — 11 NEC

7. Subtract 3,000 from amount in line 5 & enter difference in middle column. Multiply the middle column amount by 35% & enter in right column _____ {T220.42}
8. Range loads are calculated at nameplate rating. If a single range is > 8,000W & <12,000W, it still counts as 8,000W (8kW); > 12,000W, add 5% of each additional 1,000W of nameplate load. Nameplates of a counter-mounted range & up to 2 wall ovens can be added together & computed as if they were 1 range. Enter in right column _____ {220.60}
9. Enter dryer circuit at 5,000W (or nameplate rating if greater) _____ {220.54}
10. Enter larger of fixed space heating or AC load _____ {220.60}

11–18. Enter nameplate ratings of appliances that are fixed in place. For appliances rated in amps, multiply amps times voltage to determine watts. If nameplate ratings unknown, use estimates in T4 _____ {220.53}

19. Enter total load of fixed appliances _____ {220.53}
20. If there are < 4 fixed appliances, enter number from line 19 in right column _____ {220.53}
21. If there are ≥ 4 fixed appliances, multiply line 19 by 75% & enter in right column _____ {220.53}
22. Add 25% of the largest motor load. Skip this step if a nameplate rated AC is largest load since number has already been factored into nameplate min conductor ampacity _____ {220.18A}
23. Add numbers in third column _____ {220.40}
24. Divide line 23 by 240 to find req'd min amperage _____ {220.40}

TABLE 2	LOAD CALCULATIONS [T3704.2(1)] & {220.40}		
General Lighting & Receptacle Loads			
1	Sq. ft. × 3W		
Small Appliance & Laundry Loads			
2	2 small appliance circuit	3,000	
3	Additional small appliance		
4	Laundry circuit	1,500	
5	Subtotal general light, small appliance & laundry		
6	First 3,000W @ 100%	3,000	3,000
7	Balance @ 35%	× .35	=
Special Appliance Loads			
8	Range	8,000 up to 12kW nameplate	
9	Dryer	5,000 (or nameplate if >)	
10	Heating or AC @ 100%		

TABLE 2	LOAD CALCULATIONS [T3704.2(1)] & {220.40} (CONT.)		
Appliances Fastened in Place			
11	Water heater		
12	Microwave		
13	Dishwasher		
14	Compactor		
15	Disposer		
16	Attic fan		
17	Spa–per manu.		
18	Other		
19	Subtotal		
20	If <4 appliances, enter subtotal @100% *or*		
21	If ≥4 appliances, enter subtotal × 75%		
22	Largest motor × 25%		
23	Total load		
24	Total load ÷ 240V = SERVICE AMPS		

Size Requirements–General	09 IRC	11 NEC
☐ Min size for SFD 100A _____	[3602.1]	{230.79C}
☐ Service conductors adequate for load served_____	[3602.1]	{230.42}
☐ Feeders adequate for load served _____	[3701.2]	{215.2A1}
☐ Branch circuits adequate for load served _____	[3701.2]	{210.19A1}

The "optional" method is simpler & can be used to determine if an existing service is adequate for expansion. In the NEC, these methods apply to both services & feeders. In the IRC, the "long form" method, ***T2,*** *is used for feeders per section E3704 & the "optional" method,* ***T3,*** *is used for services per section E3602. NEC 220.83 provides a specific method for evaluating the adequacy of an existing service for new air-conditioning loads.*

TABLE 3	MIN. SIZE OF ELECTRICAL SERVICE [T3602.2] & {220.82}	
1. Indoor sq. ft. × 3VA/ft.		
2. Min. 2 small appliance circuits @ 1,500VA each	3,000	
3. Laundry circuit @ 1,500VA	1,500	
4. Nameplate VA of fixed appliances:		
Dryer @ 5,000VA		
Oven(s)		
Cooktop		
Water heater		
Dishwasher		
Disposer		
Other		
5. Subtotal		
6. First 10,000VA @ 100%	10,000	10,000
7. Balance @ 40% (subtract line 6 from line 5)	× .40	=
8. Largest of heating or cooling load		
8a. Nameplate rating(s) of air-conditioning & cooling equipment OR		
8b. Heat pump nameplate if no supplemental electric heat OR		
8c. Continuous electric thermal storage @ nameplate rating OR		
8d. 100% of heat pump nameplate rating plus 65% of supplemental electric heat or central electric heat OR		
8e. Space heaters @ 65% of nameplate rating if < 4 units OR		
8f. Space heaters @ 40% of nameplate rating if ≥ 4 units		
9. Total load in VA		
10. Divide by 240 = minimum service rating		

TABLE 4 TYPICAL APPLIANCE LOADS

Use actual nameplate ratings when known. This table is for estimating purposes when appliances are not yet specified.

Appliance	Typical load (W)
Central AC or heat pump	1,800 per ton
Dishwasher	1,200
Food waste disposer	900
Trash compactor	1,200
Microwave	1,500
Central furnace	1,000
Central vacuum	1,500
Electric clothes dryer	5,000
Water heater	4,500
Electric cooktop	3,600
Single wall oven	4,800
Double wall oven	8,000
Pool pump	2,000
Well pump	2,000

Optional Method (Short Form) **11 NEC**

1. 3W per ft. (exclude garage & covered patios) _____ {220.82B1}
2. Min 2 small-appliance circuits at 1,500W each, each additional small appliance circuit at 1,500W _____ {220.82B2}
3. Min 1 laundry circuit at 1,500W _____ {220.82B2}
4. Nameplate ratings of fixed appliances (see T4 if ratings not known); these include full nameplate rating of ranges & ovens without applying reductions allowed in the "long form" method _____ {220.82B3}
5. Enter sum of items 1–4 _____ {220.82B}
6. 100% of first 10,000VA _____ {220.82B}
7. Subtract line 6 from line 5, multiply by 40% & enter in right column _____ {220.82B}
8. Determine largest of the heating or cooling load. When using nameplate rating of heat pumps or AC, multiply "minimum circuit ampacity" times the voltage (240). If only size (tonnage) is known, refer to T4 _____ {220.82C}
9. Add numbers in right column & enter total _____ {220.82A}
10. Divide by 240 = amperage

GROUNDING ELECTRODES

Grounding electrodes are metal conducting objects through which a direct connection to earth is established. These electrodes provide a path for lightning and help reduce electrical noise on communications equipment. The most common grounding electrodes in residential construction are metal underground water piping, ground rods, and concrete-encased electrodes.

Grounding Electrode System (GES) F6	09 IRC	11 NEC
☐ Use all electrodes in F6 when present on premises	[3608.1]	{250.50}
☐ Electrodes bonded together form a single system F6	[3608.1]	{250.50}
☐ Size electrode bonding conductors per GEC rules	[3610.1]	{250.53C}
☐ Underground gas pipe not OK as electrode	[3608.6]	{250.52B1}

Water Pipe	09 IRC	11 NEC
☐ Metal water pipe if ≥10 ft. in direct contact with soil	[3608.1.1]	{250.52A1}
☐ Bond around water meters, filters, etc.	[3608.1.1.1]	{250.53D1}
☐ Water pipe cannot be sole electrode	[3608.1.1.1]	{250.53D2}
☐ Metal well casing that is not bonded to metal pipe (e.g., plastic water service from well) OK as electrode	[3608.1.1]	{250.52A8}

Pipes & Rods	09 IRC	11 NEC
☐ Rods min 8 ft. in contact with soil F6	[3608.1.4.1]	{250.53G}
☐ Pipe electrodes min 3/4 in. diameter	[3608.1.4]	{250.52A5}
☐ Unlisted ground rods min 5/8 in. diameter	[3608.1.4]	{250.52A5}
☐ Listed rods min 1/2 in. diameter	[3608.1.4]	{250.52A5}
☐ Drive rods vertical & fully below grade EXC	[3608.1.4.1]	{250.53G}
• If bedrock encountered, rod may be buried horizontally 2 1/2 ft. deep or driven at 45° angle	[3608.1.4.1]	{250.53G}
• Clamp above grade OK if protected F6–10	[3608.1.4.1]	{250.53G}
☐ If rod resistance > 25 ohms, install 2nd rod min 6 ft. from first & bond to 1st rod	[3608.4]	{250.56}

Recommended spacing 2× rod length, i.e., 16 ft.

Concrete-Encased Electrode F6	09 IRC	11 NEC
☐ Ufer = 20ft #4 or larger rebar near bottom of footing or 20 ft. 4 AWG or larger Cu wire near bottom of footing	[3608.1.2]	{250.52A3}
☐ Ufer must be used if present during construction	[3608.1]	{250.50}
☐ Ufer not req'd in existing building if concrete would have to be disturbed to gain access	[3608.1X]	{250.50X}
☐ Ufer concrete encasement min 2 in.	[3608.1.2]	{250.52A3}
☐ OK to bond sections of rebar with ordinary steel tie wires	[3608.1.2]	{250.52A3}
☐ Where multiple concrete-encased electrodes are present, only 1 req'd to be bonded to GES	[3608.1.2][5]	{250.52A3}
☐ Metal building frame OK as electrode if bonded to Ufer or if ≥ of steel 10 ft. in contact with earth with or without concrete encasement	[n/a]	{250.52A2}

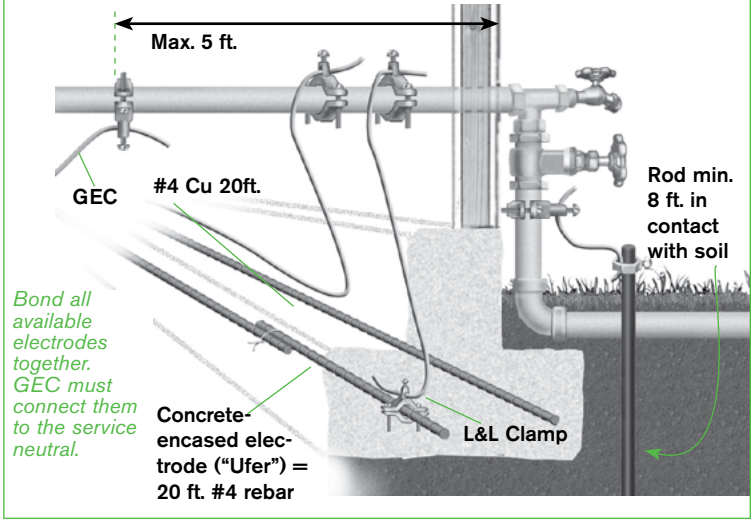
GROUNDING ELECTRODE CONDUCTORS (GECs)

A GEC connects the system of metal grounding electrodes in earth to the electrical system. It must have adequate size and protection to withstand the environmental and electrical forces imposed on it. Individual conductors can be run to each electrode of the GES, or a single conductor can be run to one of them or to the conductor that bonds the electrodes to each other.

Locations	09 IRC	11 NEC
☐ GEC must connect to EGCs, service entrance enclosures, service neutral & grounding electrodes	[3607.4]	{250.24D}
☐ Connect to service neutral anywhere from service point to bonded neutral in service disconnect	[3607.2]	{250.24A1}
☐ Bare Al not OK in masonry or earth	[3610.2]	{250.64A}
☐ Where outside, no Al ≤ 18 in. of earth	[3610.2]	{250.64A}
☐ Connection to metal water pipe that is part of GES not > 5 ft. after water entry to building F6	[3608.1.1]	{250.52A1}

FIG. 6

Grounding Electrode System (GES)



Connections	09 IRC	11 NEC
☐ No splices between service & GES EXC	[3610.1]	{250.64C}
• Listed irreversible compression connectors or exothermic welding OK	[3610.1X]	{250.64C}
☐ GEC can connect to any electrode of GES	[3610.1]	{250.64F}
☐ Buried clamps L&L for direct burial (marked "DB") F6	[3611.1]	{250.70}
☐ Cu water tubing clamps L&L for Cu tubing	[3611.1]	{250.70}
☐ Ufer clamps L&L for rebar & encasement F6	[3611.1]	{250.70}
☐ Strap-type clamps suitable only for indoor telecommunications	[3611.1]	{250.70}
☐ Max 1 conductor per clamp unless listed for more	[3611.1]	{250.70}
☐ Connections must be accessible EXC F6	[3611.2]	{250.68A}
Buried or encased connections F6	[3611.2]	{250.68AX}

Note: Rebar can be brought through the top of a foundation in a protected location, such as the garage, to provide an accessible point for the GEC to attach to the Ufer. The GEC can also be brought into the foundation and connect to the Ufer with L&L clamps or by exothermic welding.

Protection F7–10	09 IRC	11 NEC
☐ 8 AWG must be protected by raceway or armor F8,9	[T3603.1]	{250.64B}
☐ 6 AWG OK unprotected if not subject to damage & following building contour F7	[T3603.1]	{250.64B}
☐ Bond each end of metal raceway enclosing GEC F9	[T3603.1]	{250.64E}
Size	**09 IRC**	**11 NEC**
☐ Size per service conductor size T5 EXC	[3603.4]	{250.66}
• 6 AWG Cu largest size GEC needed if ending at rod	[T3603.1]	{250.66A}
• 4 AWG Cu largest size GEC needed if ending at Ufer	[T3603.1]	{250.66B

TABLE 5	GEC SIZING [T3603.1] & {250.66}	
Cu Service Wire (AWG)	Al Service Wire (AWG)	GEC Cu (AWG)
≤ 2	≤ 1/0	8
1 or 1/0	2/0 or 3/0	6
2/0 or 3/0	4/0 or 250kcmil	4
4/0–350kcmil	> 250–500kcmil	2
> 350–600kcmil	> 500–900kcmil	1/0

FIG. 7

FIG. 8

FIG. 9

FIG. 10

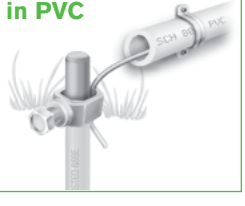


TABLE 6 EQUIPMENT GROUNDING CONDUCTORS (EGCs) [T3908.12] & {T250.122}

Size of Breaker or Fuse Protecting Circuit (Amps)	Size of Cu EGC (AWG)	Size of Al EGC (AWG)
15	14	12
20	12	10
30–60	10	8
70–100	8	6
110–200	6	4
400	3	1

EQUIPMENT GROUNDING CONDUCTORS (EGCs)

EGCs limit the voltage on equipment enclosures and provide a path for fault current. Without EGCs, the conductive frame of an appliance could remain energized if there is a fault from an ungrounded "hot" conductor. Equipment grounding provides a low-impedance path so the overcurrent device will open the circuit. The equipment grounding system has a completely different purpose from the earth grounding system. In fact, earth plays no part in helping clear faults.

General	09 IRC	11 NEC
☐ EGC must provide effective ground-fault current path	[3908.4]	{250.4A5}
☐ Earth is not an effective ground-fault current path	[3908.5]	{250.4A5}
☐ Size EGCs per **T6**	[3908.12]	{250.122A}
☐ RMC, IMC, EMT, AC cable armor, electrically continuous raceways & surface metal raceways OK as EGC	[3908.8]	{250.118}
☐ Wire EGCs can be bare, covered, or insulated **F16**	[3908.8]	{250.118}
☐ Insulation on EGC green or green with yellow stripes	[n/a]	{250.119}
☐ EGC > 6 AWG OK to strip bare for entire exposed length or use green tape or labels at termination of wire	[n/a]	{250.119A}
☐ FMC & LFMC OK as EGC for non-motor circuits in combined lengths to 6 ft. with grounding fittings **F60,61**	[3908.8.1&2]	{250.118}
☐ Remove paint from threads & other contact surfaces for field-installed equipment such as ground terminal bars	[3908.17]	{250.12}
☐ EGCs must run with other conductors of circuit EXC	[3406.7]	{300.3B}
• Replacing nongrounding receptacles (see **p.60**)	[n/a]	{250.130C}
☐ Neutral not to be used for grounding equipment EXC	[3908.7]	{250.142B}
• Existing ranges & dryers	[n/a]	{250.142BX1}

BONDING

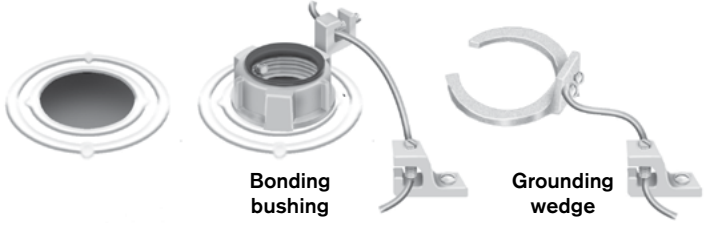
Bonding ensures electrical continuity to limit voltage potential between conductive components. On the *line side* (ahead of the main disconnect F15), it provides a path back to the utility transformer for faults on service conductors and to limit voltage potential to other systems, such as telephones or CATV. On the *load side* (after the main overcurrent protection F15), bonding and equipment grounding provide a path to clear faults and protect against shocks.

Bonding & Equipment Grounding Methods	09 IRC	11 NEC
☐ Use listed connectors, terminal bars, exothermic welding, machine screws engaging 2 threads or secured with nut, or thread-forming machine screws engaging 2 threads. Not OK to use sheet metal or drywall screws	[3908.15][6]	{250.8A}
☐ Connections may not depend solely on solder	[3908.13]	{250.8B}
☐ Clean nonconductive coatings from contact surfaces	[3908.17]	{250.12}

Line-Side Bonding F11, 12, 15	09 IRC	11 NEC
☐ Bond all service equipment, raceways & cable armor	[3609.2]	{250.92A}
☐ Bond metal GEC enclosures at each end	[T3603.1]	{250.64E}
☐ Threaded fittings OK for bonding service conduit	[3609.4.2]	{250.92B2}
☐ Meyers hub OK for bonding service conduit F11	[3609.4.2]	{250.92B2}
☐ Standard locknuts alone not sufficient on line side of service F11	[3609.4.3]	{250.92B2}
☐ Bonding locknuts OK if no remaining concentrics F11	[3609.4.4]	{250.92B4}
☐ Jumpers req'd around concentric knockouts or reducing washers on line side of service F12, 15	[3609.4.4]	{250.92B4}[7]
☐ Service neutral can bond line-side equipment	[3609.4.1]	{250.142A}
☐ Size line-side bonding jumpers per T5	[3609.5]	{250.102C}
☐ Service enclosure main bonding jumper must connect enclosure, service neutral & equipment grounds F15	[3607.5]	{250.24B}

FIG. 11 Fittings with Clean Holes

FIG. 12 Fittings with Concentric Knockouts

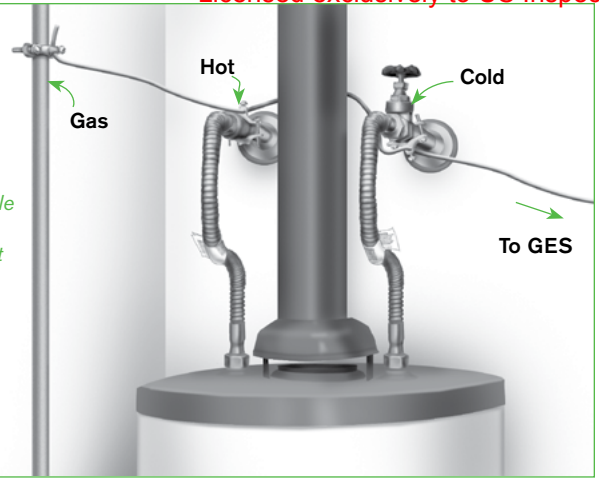


Load-Side Bonding	09 IRC	11 NEC
☐ Bond any metal piping system capable of becoming energized, including hot & cold water & gas F13	[3609.6&7]	{250.104}
☐ Size water pipe bonding per T5	[3609.6]	{250.104A1}
☐ Size gas pipe bonding per T6	[3609.7]	{250.104B}
☐ Bond metal well casings to EGC of pump motor	[n/a]	{250.112M}

FIG. 13

Bonding Interior Piping

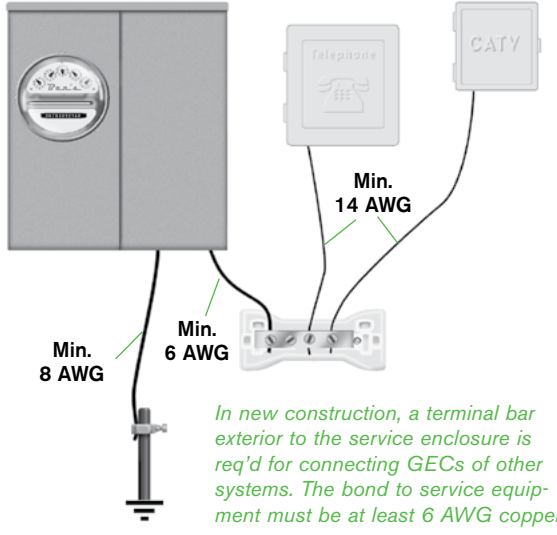
Interior piping systems capable of becoming energized must be bonded. Connecting them at a gas water heater provides an easy way to check for compliance.



Intersystem Bonding	09 IRC	11 NEC
☐ Min 6 AWG Cu bond to CATV or phone electrodes **F14**	[3609.3][8]	{800.100D}
☐ Bond lightning protection system to GEC	[n/a]	{250.106}
☐ Intersystem bonding access req'd external to service equipment & separate structure disconnecting means	[3609.3]	{250.94}
☐ Must accept min 3 conductors & be terminal or bonding bar electrically connected to meter or service enclosure	[3609.3][8]	{250.94}
☐ Existing buildings raceway or GEC OK as bond point	[n/a][8]	{250.94X}
☐ Bonding device not to interfere with enclosure cover	[3609.3]	{250.94}

FIG. 14

Intersystem Bonding



In new construction, a terminal bar exterior to the service enclosure is req'd for connecting GECs of other systems. The bond to service equipment must be at least 6 AWG copper.

In existing construction, the phone and CATV bonding conductors can be secured to a tap on the grounding electrode conductor, or to the exterior of the service enclosure or to a nonflexible metallic service riser.

PANELBOARDS & CABINETS

What is commonly called an "electrical panel" is referred to as a panelboard (NEC 408) inside a cabinet (NEC 312). See **p.9** for working space requirements.

Clearances & Location	09 IRC	11 NEC
☐ No panels or OCPDs in clothes closet or bathroom	[3405.4]	{240.24D&E}
☐ No panels or OCPDs over steps of a stairway	[3405.4][9]	{240.24F}
☐ OCPDs readily accessible & max height 6 ft. 7 in.	[3705.7]	{240.24A}

Enclosures	09 IRC	11 NEC
☐ Enclosures weatherproof in wet or damp locations	[3907.2]	{312.2A}
☐ Surface-mounted wet or damp location metal enclosures min 1/4 in. air gap between enclosure & wall	[3907.2]	{312.2A}
☐ Equipment rated for dry or damp locations must be protected against damage from weather during construction	[3404.5]	{110.11}
☐ Open knockouts & twistouts durably filled EXC	[3404.6]	{110.12A}
• Manu holes for mounting OK	[3404.6&3907.5]	{110.12A}
☐ Protect bus bars & other internal parts from contamination (paint or plaster) during construction	[3404.7]	{110.12B}
☐ Max setback in noncombustible wall 1/4 in.	[3907.3]	{312.3}
☐ Flush (no setback) in combustible (wood-frame) wall	[3907.3]	{312.3}
☐ Max plaster gap at side of flush mount panel 1/8 in.	[3907.4]	{312.4
☐ Field labeling to distinguish each circuit from all others	[3706.2]	{408.4}
☐ Labeling not based on transient conditions	[3706.2][10]	{408.4}
☐ Unused (spare) breakers labeled	[3706.2][11]	{408.4}

Grounding & Bonding	09 IRC	11 NEC
☐ Bond neutral bar to enclosure & EGCs in service **F15**	[3607.5]	{250.24B}
☐ Isolate neutrals in subpanels **F16**	[3607.2 & 3908.6]	{250.24A5}
☐ Grounding terminal bar req'd if wire EGCs present **F16**	[n/a]	{408.40}
☐ Continuity of neutral not to depend on enclosures	[3406.11][12]	{200.2B}
☐ Each neutral conductor req's individual terminal	[3706.4]	{408.41}

OCPDs & Wiring	09 IRC	11 NEC
☐ Panels req OCPD line side of bus **F15**	[3706.3]	{408.36}
☐ Breakers listed or classified AMI for panel	[3403.3]	{110.3B}
☐ Single-pole breakers with approved handle ties OK for 240V circuits **F16**	[n/a]	{240.15B2}
☐ All multiwire circuits req handle tie or single handle	[3701.5.1][13]	{210.4B}
☐ Handle tie req'd for 2 circuits to receptacles on same yoke	[n/a]	{210.7B}
☐ All conductors of multiwire circuit must be grouped (wire ties or other means) inside panel EXC **F16**	[3701.5.2][14]	{210.4D}
• Cable systems where grouping is obvious **F16**	[3701.5.2X][14]	{210.4DX}
☐ Backfed breakers secured in place EXC	[3706.5]	{408.36D}
• Output circuits from utility interactive PV inverter	[n/a]	{705.12D6}
☐ Torque all breakers & terminals AMI	[3403.3]	{110.3B}
☐ Antioxidant on Al conductors AMI	[local]	{local}
☐ Secure each cable entering panel AMI **F15,16**	[3907.8]	{312.5C}
☐ Splices & taps in panels OK to 40% fill	[3907.1]	{312.8}
☐ Apply warning label to enclosure identifying power source of feed-through conductors	[n/a]	{312.8}[15]

*Click **here** to view a copy of the UL Marking Guide for Panelboards*

*Click **here** to view a copy of the UL Marking Guide for Circuit Breakers*

Beware of electrical shorts!

FIG. 15

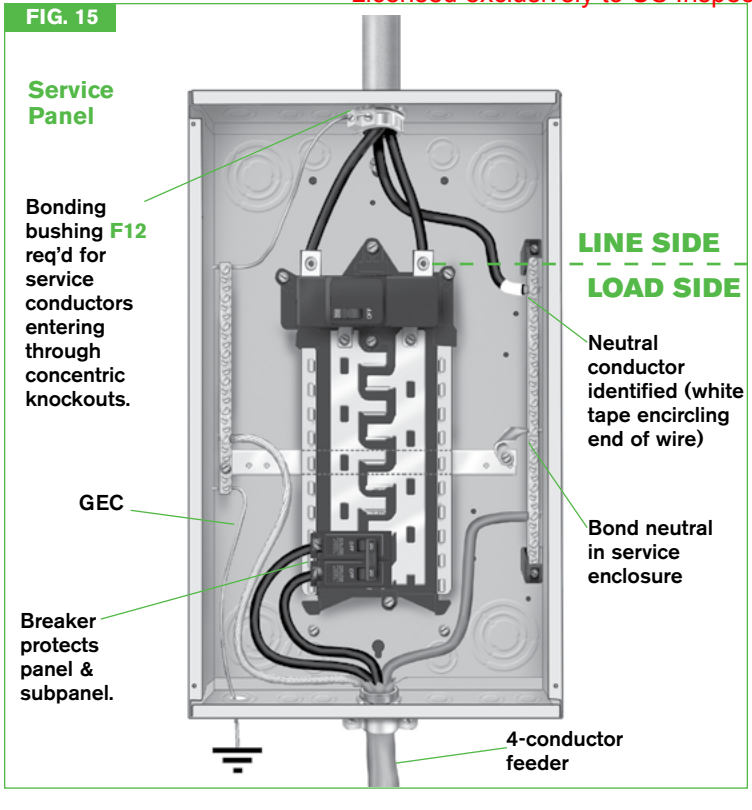


FIG. 16

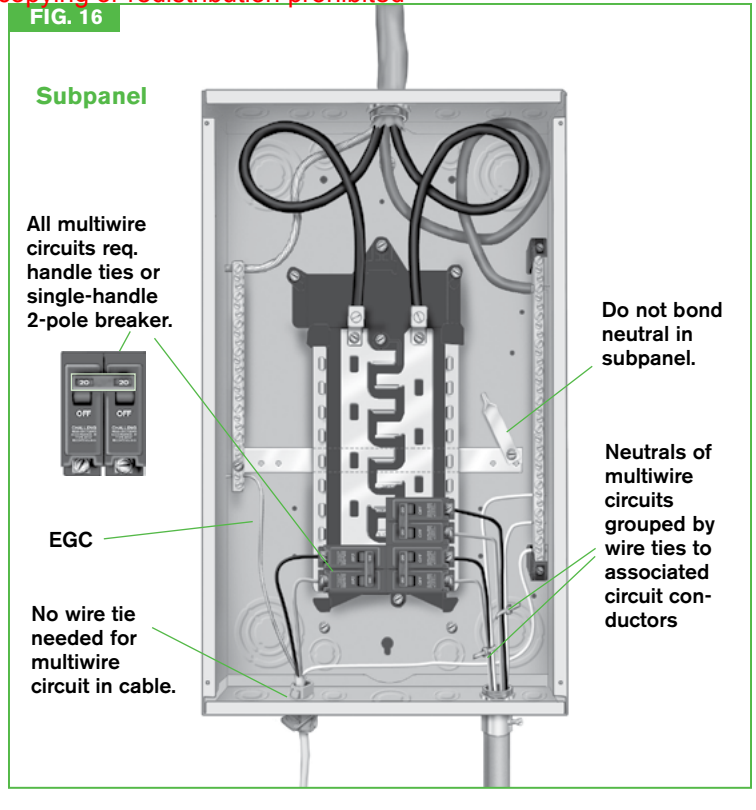
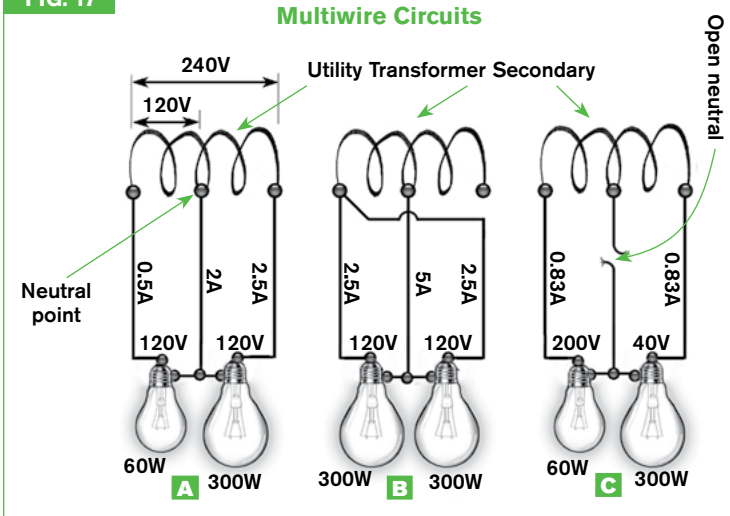


FIG. 17



A PROPER CIRCUIT 2 unequal loads are fed by a 3-wire circuit. The neutral carries the imbalance between the 2 loads.

B OVERLOADED NEUTRAL Without voltage potential between the hot conductors, the neutral carries the sum of the loads. In a 3-conductor NM cable, the black & red wires must originate from different poles or the neutral can be overloaded because it carries the sum of the currents.

C OPEN NEUTRAL Two unequal loads in series across 240V from the transformer. The load with lowest resistance sees the lower voltage. Voltage at each load depends on other loads and is unstable.

3-WIRE EDISON CIRCUITS (MULTIWIRE)

Standard electrical services to 1- and 2-family dwellings originate at a utility transformer with two ungrounded "hot" conductors and a neutral derived from the center of the transformer's secondary coil, as depicted in **F17**. The neutral is connected to earth and is referred to as the "grounded" conductor. The neutral limits the voltage on either of the hot conductors to 120V to ground. If the neutral is broken or loose, voltages become erratic, as in **F17 C**. TV sets, motors, and computers don't do well with fluctuating voltages. The utility company should be notified if there are signs of unstable voltage, such as incandescent bulbs growing brighter or dimmer as other loads change. Not only is the service to the house a "3-wire" circuit, but 120V branch circuits are often installed with shared neutrals, which are then known as multiwire circuits.

Multiwire Circuits	**09 IRC**	**11 NEC**
☐ Hot conductors must originate from opposite poles	[3501]	{100}
☐ All conductors must originate from same panel	[3701.5]	{210.4A}
☐ Multiwire neutrals may not feed through devices such as receptacles (pigtail lead from neutral to device in box)	[3406.10.2]	{300.13B}
☐ All multiwire circuits req handle tie or single handle	[3701.5.1][13]	{210.4B}
☐ Handle tie req'd for 2 circuits to receptacles on same yoke	[n/a]	{210.7B}
☐ All conductors of multiwire circuit must be grouped (wire ties or other means) inside panel EXC **F16** _	[3701.5.2][14]	{210.4D}
• Cable systems where grouping is obvious **F16**	[3701.5.2X][14]	{210.4DX}

ARC-FAULT CIRCUIT INTERRUPTERS (AFCIs)

An AFCI provides fire protection by opening the circuit when an arcing fault is detected F18. They look similar to GFCI breakers F26, and AFCIs do provide some protection against shock hazards, though not at the level req'd for GFCIs. The 2008 NEC and 2009 IRC greatly expanded the areas that req AFCI protection. The time to plan for the AFCIs is during the rough wiring, so that separate cables are provided for the circuits requiring AFCI protection. Not all brands and models of AFCI are compatible with multiwire circuits.

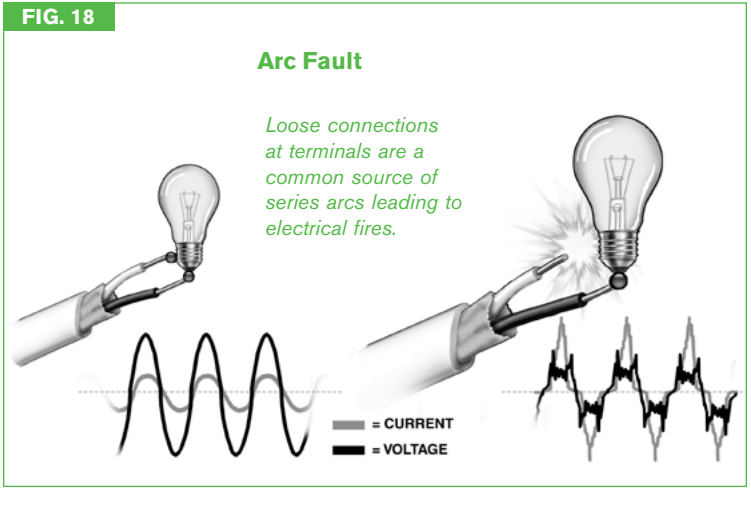
Beginning January 1, 2008, all AFCIs were req'd to be "combination" type rather than the original "branch/feeder" type. Combination AFCIs provide a broader range of protection. Outlet types are mentioned in the codes, though at press time these were not yet available.

Acceptance of the AFCI code provisions varies widely by jurisdiction. Be sure to check with your local building department for their current AFCI requirements before beginning a wiring project.

AFCI Protection	**09 IRC**	**11 NEC**
☐ Combination-type AFCI req'd for 15A & 20A branch circuits supplying outlets in family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways & similar rooms or areas EXC	[3902.11][16]	{210.12A}
• Not req'd on individual circuit for central station alarm in RMC, IMC, EMT, or steel-armored cable (type AC)	[3902.11X2]	{210.12AX2}
☐ AFCI must protect entire branch circuit EXC	[3902.11]	{210.12A}
• OK to have protection at first outlet if wiring method between breaker & outlet is RMC, IMC, EMT, or steel-armored cable (type AC) & metal outlet or junction boxes are used	[3902.11X1]	{210.12AX1}
☐ Replacement or extension of branch circuit wiring req's AFCI breaker at origin of replacement circuit or AFCI outlet device at first receptacle of existing branch circuit	[n/a]	{210.12B}[17]

Click *here* for a downloadable article on AFCIs from the authors

FIG. 18



BOXES

Boxes must be large enough to contain all the conductors and devices inside them, and sufficient wire must be brought into the box to safely make up connections. Luminaires that are supported from boxes are generally designed so their connections will be made inside the box, rather than inside the fixture canopy. Device boxes are threaded for 6–32 screws used to mount switches and receptacles. Lighting outlet boxes provide 8–32 (for luminaires) or 10–24 screws (for listed paddle fan boxes).

General	09 IRC	11 NEC
☐ Metal boxes must be grounded	[3905.2]	{314.4}
☐ Box & conduit body covers must remain accessible	[3905.11]	{314.29}
☐ Max 1/4 in. setback from noncombustible surface* F19	[3906.5]	{314.20}
☐ Box extenders OK to correct excess setback	[3906.5]	{314.20}
☐ Boxes flush with combustible surface* F19	[3906.5]	{314.20}
☐ Plaster gap max 1/8 in. for flush cover boxes F19	[3906.6]	{314.21}
☐ Min 6 in. free conductor & 3 in. past box face	[3406.10.3]	{300.14}
☐ Luminaires only in boxes designed for luminaires EXC	[3905.6]	{312.27a}
• Wall sconces ≤ 6 lb. on device boxes with 2 #6 screws	[3905.6X]	{314.27A1X}
☐ Wall luminaire boxes max weight marked if ≤ 50 lb.	[3905.6][18]	{314.27A1}
☐ Ceiling luminaire boxes req 50 lb. rating F21	[3905.7][18]	{314.27A2}
☐ Ceiling luminaires > 50 lb. req independent support	[3905.7][18]	{314.27A2}
☐ Smoke alarms OK on device boxes with 2 #6 screws	[n/a]	{314.27DX}
☐ Paddle fans req L&L paddle fan box F42	[3905.9]	{314.27C}}
☐ Boxes must be supported	[3906.8]	{314.23}
☐ PVC & EMT not OK for box support	[3906.8.5]	{314.23E&F}
☐ PVC & EMT OK for conduit body support	[3906.8.5]	{314.23E&F}
☐ Wet location boxes req listing for wet locations	[3905.12]	{314.15}
☐ Damp or wet location boxes must keep out water	[3905.12]	{314.15}

Box Fill	09 IRC	11 NEC
☐ Size sufficient to provide free space for conductors	[3905.13]	{314.16}
☐ Standard metal boxes per code tables	[3905.13.1.1]	{314.16A1}
☐ Include volume of marked mud rings & extensions	[3905.13.1]	{314.16A}
☐ Plastic boxes have volume marking	[3905.13.1.2]	{314.16A2}
☐ 4 in. (6 cu. in.) pancake OK only end of 14/2 run F21	[3905.13.2]	{314.16B}
☐ 18 cu. in. box too small for 3 12/2 Romex T8, F20	[3905.13.2]	{314.16B}

TABLE 7 BOX FILL WORKSHEET [3905.13.2] & {314.16B}

Item	Size	#	Total
#14 conductors exiting box	2.00		
#12 conductors exiting box	2.25		
#10 conductors exiting box	2.50		
#8 conductors exiting box	3.00		
#6 conductors exiting box	5.00		
Largest grounding conductor–count only 1		1	
Devices–2× times connected conductor size			
Internal clamps–1 based on largest wire present		1	
Fixture fittings–1 for each type based on largest wire			
TOTAL			

* The IRC text for section 3906.5 states that the allowed 1/4 in. setback is for walls or ceilings ***constructed*** with noncombustible material, rather than walls or ceilings ***surfaced*** with noncombustible material. The IRC also states that this section is derived from NEC 314.20, which states it the way that we do. We think the correct interpretation is as we have written it.

FIG. 19

Improper Box Installation

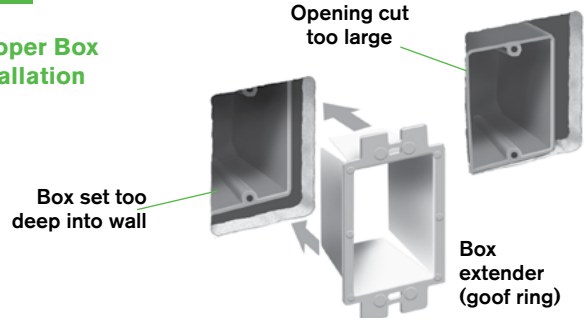
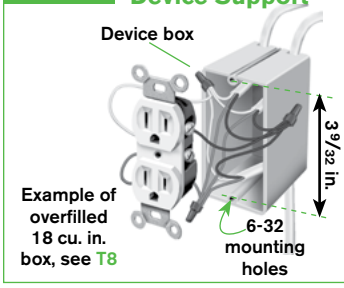
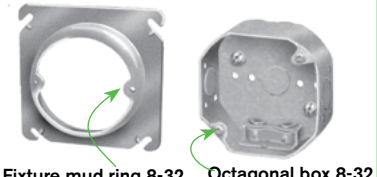


FIG. 20 **Device Support**



Fixture Support FIG. 21



Paddle fans req. 10-32 screws on L&L fan box.

Box Fill Factors T7,8

	09 IRC	11 NEC
☐ Count each conductor exiting box EXC_____	[3905.13.2.1]	{314.16B1}
EGCs from luminaires or up to 4 conductors < 14 AWG from luminaires with domed canopies _____	[3905.13.2.1X]	{314.16B1X}
☐ Unbroken conductors passing through box count as only 1 conductor EXC _____	[3905.13.2.1]	{314.16B1}
Looped unbroken conductors > 12 in. count as 2	[3905.13.2.1]	{314.16B1}
☐ Do not count pigtailed conductors to devices _	[3905.13.2.1]	{314.16B1}
☐ All internal clamps count as 1, based on largest conductor in box_____	[3905.13.2.2]	{314.16B2}
☐ Support fittings count as 1 conductor for each fitting type based on largest conductor in box_____	[3905.13.2.3]	{314.16B3}
☐ Count devices as 2 conductors based on connected wire size_____	[3905.13.2.4]	{314.16B4}
☐ All EGCs count only as 1 based on largest ___	[3905.13.2.5]	{314.16B5}

TABLE 8 BOX FILL EXAMPLE FOR F20

Item	Size	#	Total
#12 conductors exiting box	2.25	6	13.50
Largest grounding conductor–count only 1	2.25	1	2.25
Devices–2× times connected conductor size	4.50	1	4.50
Internal clamps–1 based on largest wire present	2.25	1	2.25
TOTAL			22.5

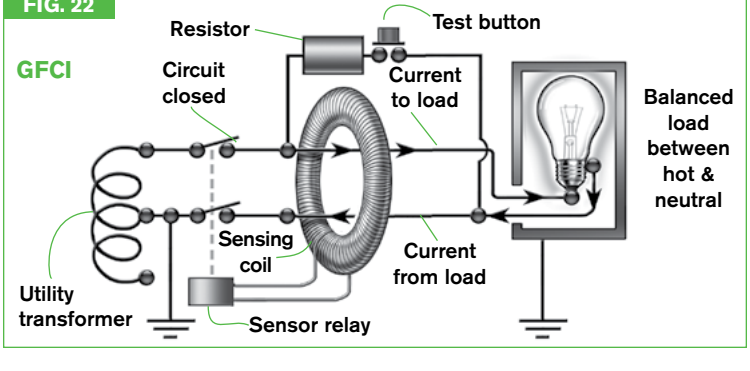
3 12/2+G Romex + device overfills 18 cu. in. box.

GROUND-FAULT CIRCUIT INTERRUPTERS (GFCIs)

A ground fault occurs when current leaks out of its normal path and finds a path back to the utility transformer through conductors that are not supposed to carry current. An example of such an abnormal path could include a human body. Ironically, even though the earth is not a sufficiently good conductor to provide a fault path that would trip a breaker, it is a good enough conductor to carry the low levels of current that can cause electrocution. GFCIs respond to very low levels of current imbalance in a circuit, such as those that occur when current returns through a person. GFCIs are designed to limit the duration of leaking current to safe levels.

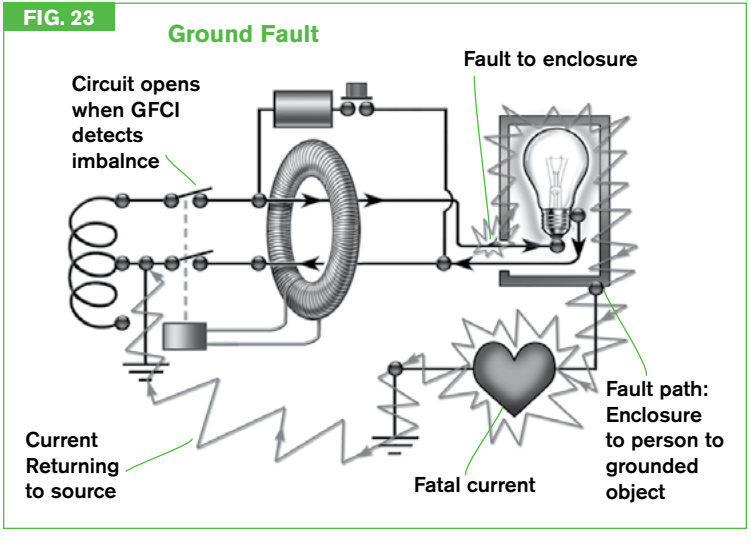
*How does a GFCI work its magic? In **F22**, equal currents are flowing to & from the load. When any electrical current flows, it generates a magnetic field. The magnetic fields generated by the flow of electrons in these 2 conductors are of opposite polarity (north & south, leaving & returning). The forces are equal & opposite & their magnetic fields cancel each other. The circuit passes through a coil of wire inside the GFCI & the GFCI accounts for the electrons on each conductor. As long as the currents are balanced, GFCI allows current on the circuit.*

FIG. 22



*During a ground fault–such as the flow of current through a person to something that is grounded–the circuit becomes unbalanced **F23**. Because the circuit is unbalanced, it produces a magnetic field that induces a small voltage on the sensing coil. The resulting current on the sensing coil signals the relay mechanism, which opens the circuit.*

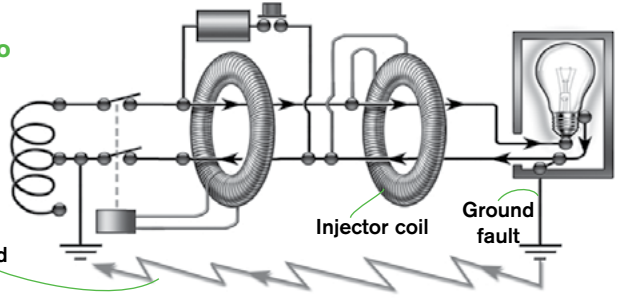
FIG. 23



*A GFCI also detects improper connections of the neutral (grounded conductor) to ground. A second "injector" coil **F24** surrounds the monitored circuit & induces a small current. Should the neutral have a downstream connection to the ground, the current will escape outside the circuit & the sensor coil circuit will be activated as described on **p.27**.*

FIG. 24

Neutral to Ground Fault

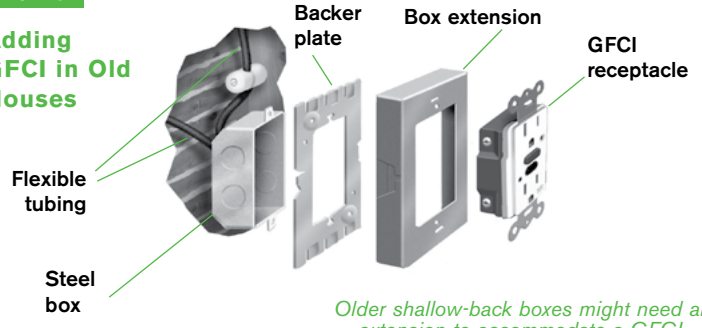


*GFCIs take more space inside a box than do conventional receptacles. When adding GFCIs to old houses with shallow boxes, it might be necessary to first add an extension box, as in **F25.***

A GFCI will operate properly without an equipment ground. The receptacle should be labeled "no equipment ground" & any downstream protected receptacles should also have that label as well as a label stating that they are GFCI protected. Labels are not req'd for properly grounded GFCI-protected receptacles.

FIG. 25

Adding GFCI in Old Houses

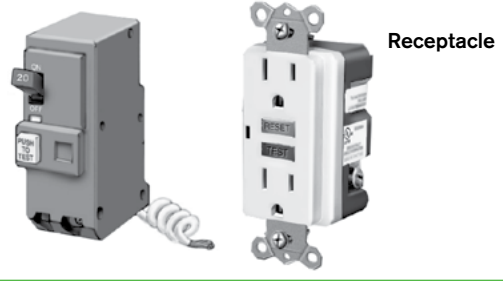


Older shallow-back boxes might need an extension to accommodate a GFCI.

*A GFCI receptacle can provide protection for other receptacles downstream on the circuit. GFCI protection can be provided by GFCI breakers or GFCI receptacles **F26**.*

FIG. 26

GFCIs



Residential GFCI Protection — 09 IRC — 11 NEC

GFCI protection is req'd for 15A & 20A receptacles in the following locations. It is not req'd for 240V receptacles or 120V-30A receptacles.

- ☐ GFCIs req'd to be in readily accessible locations _____ [n/a] {210.8A}[19]
- ☐ All bathroom receptacles _____ [3902.1] {210.8A1}
- ☐ All garage & accessory building receptacles _____ [3902.2][20] {210.8A2}
- ☐ All receptacles in unfinished basements EXC _____ [3902.5] {210.8A5}
  - • Permanently installed fire or burglar alarm system __ [3902.5X] {210.8A5X}

The 2005 NEC & 2006 IRC had exceptions for receptacles in garages & unfinished basements when those receptacles served appliances that are not easily moved, such as freezers. Those exceptions have been removed.

- ☐ All outdoor receptacles EXC _____ [3902.3] {210.8A3}
  - • GFPE circuit dedicated to nonreadily accessible receptacles for snow-melting or deicing equipment _____ [3902.3X] {210.8A3X}
- ☐ All receptacles in crawl spaces at or below grade level [3902.4] {210.8A4}
- ☐ All receptacles serving kitchen counters **F30** _____ [3902.6] {210.8A6}
- ☐ Receptacles within 6 ft. of all non-kitchen sinks _____ [3902.7][21] {210.8A7}[22]

Pools, Spas, Whirlpool Tubs & Boathouses — 09 IRC — 11 NEC

- ☐ Receptacles ≤ 20 ft. of pools & outdoor hot tubs ____ [4203.1.3] {680.22A4}
- ☐ Distance does not apply to cords that would have to pass through window or door _____ [4203.1] {680.22A5}
- ☐ Receptacles for 120V or 240V pool pump motors regardless of distance from pool _____ [4203.1.3] {680.22A4}
- ☐ Receptacles providing power to indoor spas or hot tubs __ [n/a] {680.43A3}
- ☐ Receptacles ≤ 10 ft. of indoor spas or hot tubs _____ [4203.1.5] {680.43A2}
- ☐ Pool cover motor & controller _____ [4206.11] {680.27B2}
- ☐ Hydromassage (whirlpool) tubs _____ [4209.1] {680.71}
- ☐ Underwater pool lights > 15V **F68** _____ [4206.4] {680.23A3}
- ☐ Luminaires & lighting outlets < 10 ft. horizontally from outdoor pool or spa edge unless > 5 ft. vertically above water ____ [4203.4.5] {680.22B4}

Pools, Spas, Whirlpool Tubs & Boathouses (cont.) — 09 IRC — 11 NEC

- ☐ Existing luminaires allowed < 5 ft. horizontal if > 5 ft. vertical above water & GFCI protected _____ [4203.4.3] {680.22B3}
- ☐ Outlets supplying self-contained packaged spa/hot tub or field-assembled with heating < 50A EXC _____ [4208.1] {680.44}
  - • Outlets supplying listed units with integral GFCIs ____ [4208.1] {680.44A}
- ☐ Receptacles in boathouses _____ [3902.8] {210.8A8}
- ☐ 120V or 240V boat hoists _____ [3902.9][23] {210.8C}

UL 943—the standard of safety for GFCIs—was revised in 2003, requiring GFCIs to have greater resistance to corrosion & surges. GFCIs have become more reliable & do not have the problems of "nuisance tripping" that characterized these devices in the earlier stages of their development. Thanks to their increased reliability, it is no longer necessary to have the numerous exceptions that once existed for GFCIs associated with motor loads.

The standard includes a line-load reversal test that req's the receptacle not be capable of resetting if it is miswired & a 2006 revision req's that there be no power to the face of a miswired receptacle. The contacts on newer GFCIs ensure proper resetting & prevent some miswiring that could appear from manipulation of the controls on the older GFCIs. In addition, manu installation instructions for GFCIs are now standardized for consistency. These instructions req specific methods for checking GFCI operation after installation to ensure that devices are properly wired & that they be tested on a regular basis for the life of the GFCI. As a result, these proven life savers have become more reliable than ever.

BRANCH CIRCUITS & OUTLETS

Branch circuits are the permanent wiring between the final overcurrent protective devices (fuses or breakers) and the lighting or receptacle outlets from which electrical equipment derives power. During rough-in of branch circuit wiring, care should be taken to ensure they are an adequate size for the load. Circuits for continuous loads and items such as water heaters or space heaters that are treated as continuous loads, must be sized to 125% of the load. There must be sufficient outlets for the needs of the occupants. An insufficient number of outlets could lead to the dangerous substitution of extension cords in place of permanent wiring. During rough-in, boxes are placed in the locations req'd for receptacle and lighting outlets, cables are run, and equipment grounds are connected.

Circuit Sizes, Number & Load Limitations	09 IRC	11 NEC
☐ Rule of thumb: min 1 general-purpose circuit per 500 sq. ft.	[3704.4]	{220.12}
☐ Load not to exceed rating of branch circuit	[3701.2]	{220.18}
☐ Min circuit size 125% of continuous load + 100% of noncontinous load	[3701.2]	{210.19A}
☐ Continuous load = max current for 3 hours or more	[3501]	{100}
☐ Min size for branch circuit wiring 14 AWG	[3702.13]	{210.19A4}
☐ Branch circuit ratings for other than individual circuits must be 15A, 20A, 30A, 40A, or 50A	[3702.2]	{210.3}
☐ Single piece of cord-&-plug-connected equipment not permanently fastened in place cannot exceed 80% of 15A or 20A branch circuit	[3702.3]	{210.23A1}
☐ Max single cord-&-plug-connected load on multi-receptacle circuit not to exceed 80% of circuit rating	[n/a]	{210.21B2}

Receptacle Locations–General	09 IRC	11 NEC
☐ Receptacles for specific appliances (laundry, garage door opener) within 6 ft. of appliance location	[3901.5]	{210.50C}
☐ Flexible cords not OK as fixed or concealed wiring	[3909.1]	{400.8}

Receptacles	09 IRC	11 NEC
☐ All receptacles on 15A & 20A circuits grounding type	[4002.2]	{406.4A}
☐ Receptacles for direct Al connection marked "CO/ALR"	[4002.3]	{406.3C}
☐ All req'd receptacles listed TR type EXC	[4002.14][24]	{406.12}
• Receptacles located > 5½ ft. above floor	[4002.14][24]	{406.12X}[25]
• Receptacles that are part of a luminaire	[4002.14][24]	{406.12X}[25]
• Single receptacles within dedicated space for an appliance not easily moved or duplex receptacle for 2 such appliances	[n/a]	{406.12X}[25]
• Replacement nongrounding receptacles (see **p.60**)	[n/a]	{406.12X}[25]
☐ Single receptacles rated not less than branch circuit	[4002.1.1]	{210.21B1}
☐ Multiple receptacles on branch circuit per T9	[4002.1.2]	{210.21B3}

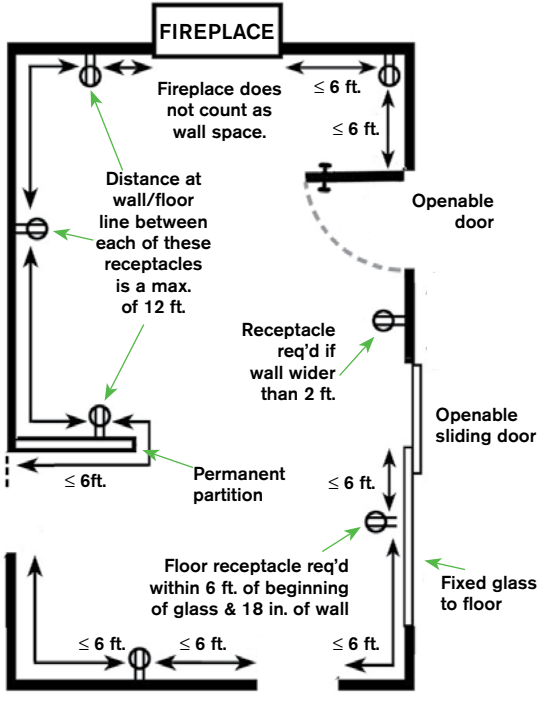
For the purposes of these rules, a duplex receptacle is 2 receptacles, not a "single" receptacle.

TABLE 9 RECEPTACLE RATINGS FOR MULTIPLE RECEPTACLES ON 1 CIRCUIT [4002.1.2] & {210.21.B3}

Circuit Rating	Receptacle Rating
15A	not over 15A
20A	15 or 20A
30A	30A
40A	40 or 50A
50A	50A

FIG. 27

6 ft. & 12 ft. Rule

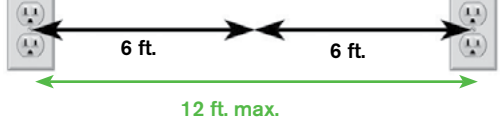


Receptacle Outlets–General Purpose F27,28	09 IRC	11 NEC
☐ Walls ≥ 2 ft. wide req receptacle	[3901.2.2]	{210.52A2}
☐ Partitions & bar-type counters count as walls F30	[3901.2.2]	{210.52A2}
☐ Doorways & fireplaces not counted as walls	[3901.2.2]	{210.52A2}
☐ Receptacle req'd within 6 ft. measured horizontally of any point along floor line	[3901.2.1]	{210.52A1}
☐ Receptacle req'd for hallways ≥ 10 ft. in length F28	[3901.10]	{210.52H}
☐ Receptacles that are part of electric baseboard heaters OK as req'd outlets	[3901.1]	{210.52}
☐ Receptacles > 5½ ft. high not OK as req'd outlets	[3901.1]	{210.52}
☐ Floor receptacles > 18 in. from wall not OK as req'd outlets	[3901.2.3]	{210.52A3}
☐ Switched receptacles installed as req'd lighting do not count as part of req'd receptacle outlets unless "half hot"	[3901.1][26]	{210.52}
☐ Receptacles req'd each wall ≥ 3 ft. in foyers > 60 sq. ft.	[n/a]	{210.52I}[27]
☐ Garages & unfinished basements req min 1 receptacle in addition to any for specific equipment	[3901.9]	{210.52G}

FIG. 28

6 ft. & 12 ft. Rule Explained

Wall receptacles serve spaces for 6 ft. on each side of receptacle. Therefore, max. spacing between wall receptacles is 12 ft.



Bathrooms

	09 IRC	11 NEC
☐ Receptacle req'd on wall or partition within 3 ft. of each basin or in side or face of cabinet ≤ 12 in. below countertop	[3901.6]	{210.52D}
☐ No face-up outlets on vanity countertop	[3901.6]	{406.4E}
☐ Listed countertop-mounted receptacles OK	[n/a]	{210.52D}[28]
☐ No receptacles within or directly over tub or shower	[4002.11]	{406.8C}
☐ Separate 20A circuit for bath receptacles only OR	[3703.4]	{210.11C3}
• Dedicated 20A circuit to each bathroom	[3703.4X]	{210.11C3X}
☐ Max rating of fixed space heater on general lighting circuit 15A circuit: 900W; 20A circuit: 1,200W	[3702.5]	{210.23A2}

Laundry

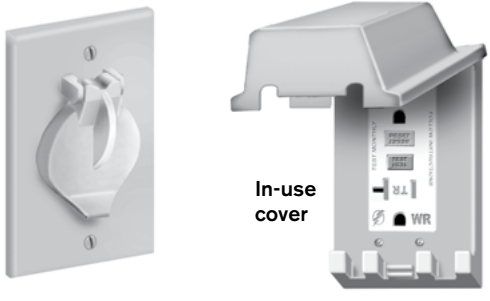
	09 IRC	11 NEC
☐ Min 1 20A circuit for laundry receptacles	[3703.3]	{210.11C2}
☐ No non-laundry outlets on laundry receptacle circuit	[3703.3]	{210.11C2}
☐ Receptacle within 6 ft. of intended appliance location	[3901.5]	{210.50C}
☐ Electric dryer min 30A circuit (10 AWG Cu, 8 AWG Al)	[T3704.2(1)]	{220.54}
☐ Electric dryer req's 4-conductor branch circuit EXC	[3908.7]	{250.140}
• Existing 3-wire circuits allowed to remain in use	[n/a]	{250.140X}

Outdoors

	09 IRC	11 NEC
☐ Receptacle accessible from grade req'd at front & rear of dwelling max 6½ ft. above grade	[3901.7]	{210.52E1}
☐ Receptacle req'd at balconies with interior access EXC [3901.7][29]		{210.52E3}
• Not req'd if balcony < 20 sq. ft.	[3901.7]	{n/a}[30]
☐ Receptacles in damp or wet locations req'd to be listed weather-resistant type	[4002.8][31]	{406.8A&B}
☐ Outdoor damp location receptacle (e.g., protected porch) req's weatherproof cover **F29**	[4002.8]	{406.8A}
☐ Wet location 15A & 20A receptacles req in-use covers **F29**	[4002.9]	{406.8B1}

FIG. 29

Outdoor Covers



Lighting Outlets (see p.36 for Switches)

	09 IRC	11 NEC
☐ Wall-switch controlled lighting outlets req'd in all habitable rooms & bathrooms	[3903.2]	{210.70A1}
☐ Habitable room lighting outlets may be switched receptacle except in kitchen & bathroom	[3903.2X1]	{210.70A1X1}
☐ Occupancy-sensor wall switches with manual override feature OK	[3903.2X2]	{210.70A1X2}
☐ Wall-switch controlled lighting outlets req'd in hallways, stairways, attached garages & detached garages with power	[3903.3]	{210.70A2}
☐ Min 1 wall-switched lighting outlet in garage	[3903.3]	{210.70A2a}
☐ Lighting outlet req'd on exterior side grade level doors	[3903.3]	{210.70A2b}
☐ Lighting outlet req'd at garage egress doors	[3903.3]	{210.70A2b}
☐ Lighting outlet not req'd at garage vehicle doors	[3903.3]	{210.70A2b}

KITCHENS

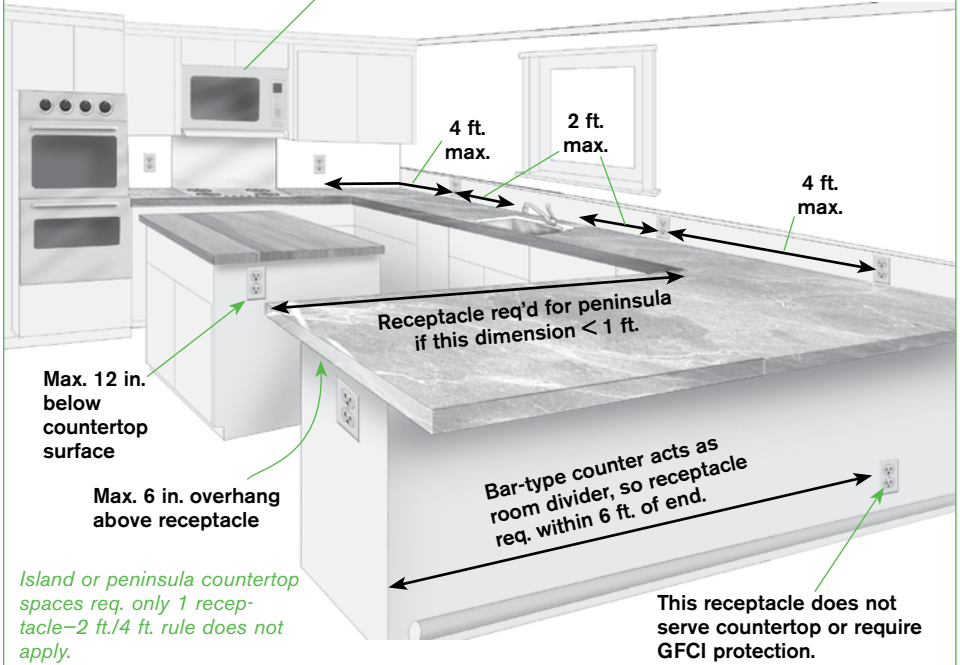
A minimum of 2 20A small-appliance branch circuits are req'd for portable appliances that are used in kitchens and dining areas. These circuits are in addition to those that supply lighting or permanently installed appliances. Portable kitchen appliances have short cords so they are not as likely to be run across cooktops or sinks or to hang down in the reach of children. A receptacle is needed to serve every countertop 1 ft. or more in width.

Branch Circuits	09 IRC	11 NEC
☐ Min 2 20A small-appliance circuits req'd	[3703.2]	{210.11C}
☐ Small-appliance circuits must serve refrigerator & all countertop & exposed wall receptacles in kitchen, dining room & pantry EXC	[3703.2]	{210.52B1}
• Refrigerator OK on individual branch circuit ≥ 15A	[3703.2X]	{210.52B1X2}
☐ Switched receptacle for dining room light OK on non-small-appliance circuit	[3901.3X1]	{210.52B1X1}
☐ No other outlets (including lights) on small appliance branch circuits EXC	[3901.3.1]	{210.52B2}
• Receptacles for clock or gas range ignition OK	[3901.3.1X]	{210.52B2X}
☐ Dishwasher & disposer req separate circuits if combined rating exceeds branch circuit rating	[3701.2]	{210.19A1}
☐ Circuits for ranges ≥ 8.75kW min 40A 240V	[3702.9.1]	{210.19A3}

Receptacles for Countertop Spaces	09 IRC	11 NEC
☐ Receptacles req'd for wall counter spaces ≥ 12 in. wide	[3901.4.1]	{210.52C1}
☐ Countertop spaces separated by sinks or ranges considered separate countertop spaces F30	[3901.4.4]	{210.52C4}
☐ Spacing so no point > 24 in. from receptacle F31	[3901.4.1]	{210.52C1}
☐ Area behind sink or range considered countertop space if ≥ 12 in. to wall F32 or ≥ 18 in. to corner F33	[3901.4.1X]	{210.52C1X}
☐ Max 20 in. above countertop	[3901.4.5]	{210.52C5}
☐ Peninsulas req receptacle if long dimension ≥ 24 in. & short dimension > 12 in., measured from connecting edge F30	[3901.4.3]	{210.52C3}
☐ Island & peninsula countertop spaces min 1 receptacle per space–no 24 in. rule F30	[3901.4.2&3]	{210.52C2&3}
☐ Sink or range with < 12 in. behind divides counters into separate spaces for above rule	[3901.4][32]	{210.52C4}
☐ Island & peninsula receptacles OK ≤ 12 in. below counter overhanging ≤ & no means of installing receptacle in overhead cabinet F30	[3901.4.5X]	{210.52C5X}
☐ No face-up countertop receptacles	[3901.4.5]	{406.4E}
☐ GFCI protection for all receptacles serving countertops	[3902.6]	{210.8A6}

FIG. 30

Kitchen Receptacles



Island or peninsula countertop spaces req. only 1 receptacle–2 ft./4 ft. rule does not apply.

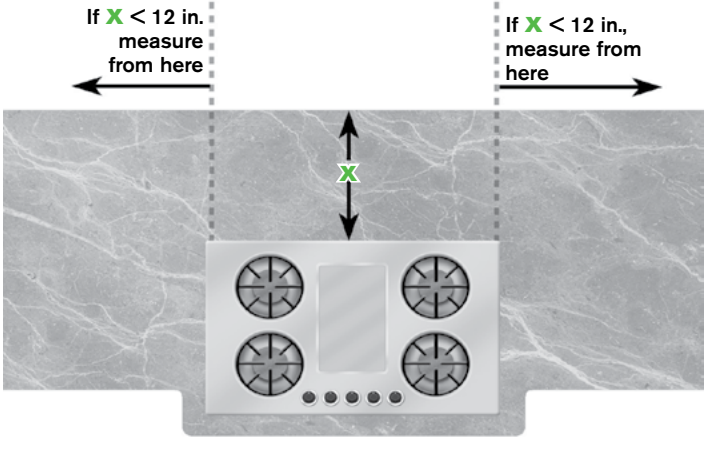
FIG. 31

2 ft./4 ft. Rule Explained

Wall countertop receptacles serve spaces for 2 ft. on each side of the receptacle. Therefore, the max. spacing between receptacles on the same countertop space is 4 ft.

FIG. 32 Extended Range or Sink

*If **X** ≥ 12 in., countertops are not considered separate spaces & the 2 ft./4 ft. rule applies to the entire countertop.*



*When **X** is < 12 in. on an island or peninsula countertop, the countertop spaces to each side of the sink or range are considered separate spaces, and each space is required to be served by a receptacle outlet.*

FIG. 33 Corner Range or Sink

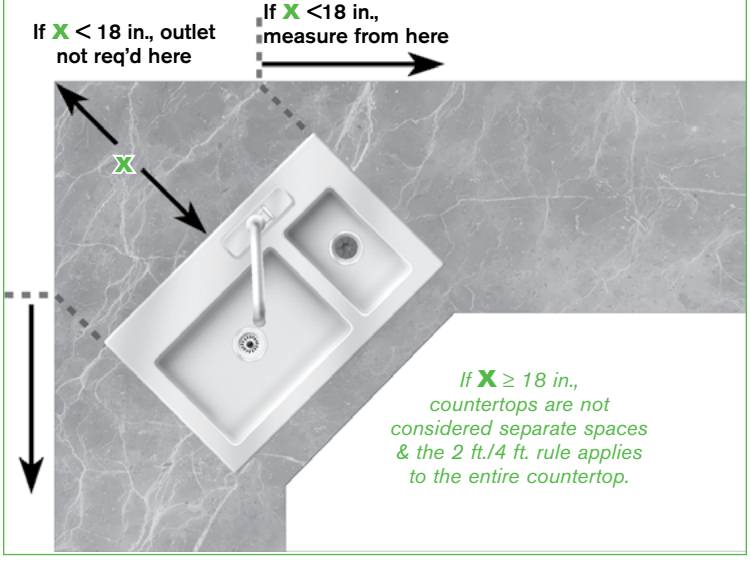
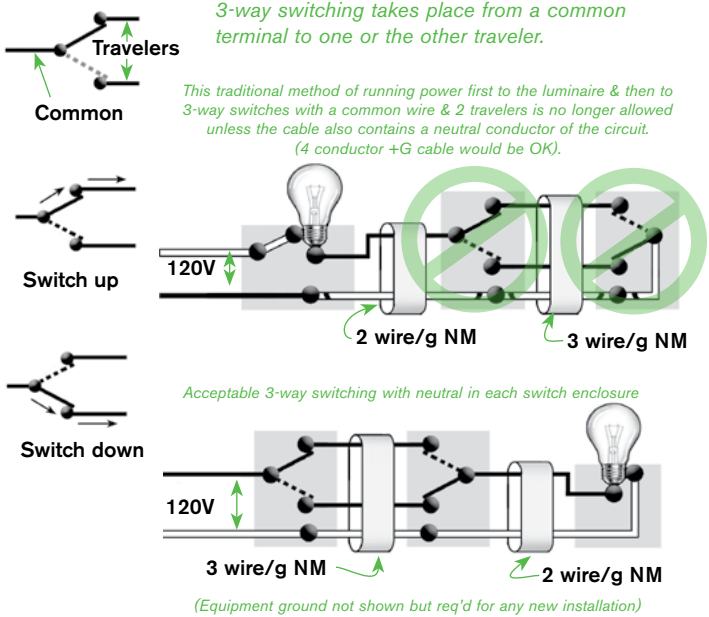


FIG. 34

3-Way Switch

3-way switching takes place from a common terminal to one or the other traveler.



(Equipment ground not shown but req'd for any new installation)

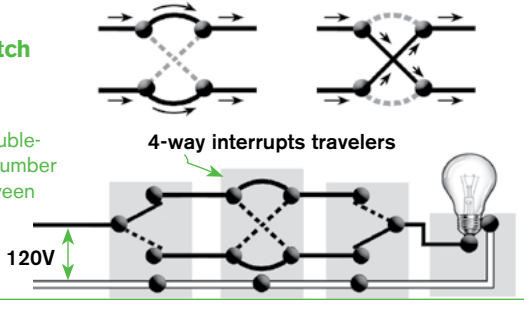
SWITCHES

General	09 IRC	11 NEC
☐ All switching in ungrounded conductors F34,35	[4001.8&9]	{404.2A&B}
☐ Provide neutral in switchbox EXC	[n/a]	{404.2C}[33]
• In raceway with sufficient room to add neutral	[n/a]	{404.2CX}[34]
• Where switch not enclosed by building finishes	[n/a]	{404.2CX}[34]
☐ Snap switches & dimmers req grounding EXC	[4001.11.1]	{404.9B}
• Replacements where no grounding means present OK with plastic faceplate or GFCI protection	[4001.11.1X]	{404.9BX}
☐ Grounding OK by screws to grounded metal box	[4001.11.1]	{404.9B1}
☐ Metal faceplates must be grounded to switch	[4001.11.1]	{404.9B}
☐ Faceplate must completely cover wall opening	[4001.11]	{404.9A}
☐ Switch at each entrance of stairs with ≥ 6 risers	[3903.3]	{210.70A2c}
☐ Dimmers only for incandescent lights not receptacles	[4001.12]	{404.14E}
☐ Current-carrying conductors of circuit grouped F34	[3406.7]	{300.3B}
☐ Re-identify ungrounded white or gray wires F34	[3407.3X]	{200.7C}
☐ "CO/ALR" switch req'd if direct Al wire connection	[4001.2]	{404.14C}

FIG. 35

4-Way Switch

A 4-way switch is a double-pole double-throw switch. Any number can be placed between the 2 3-ways.



LIGHTING

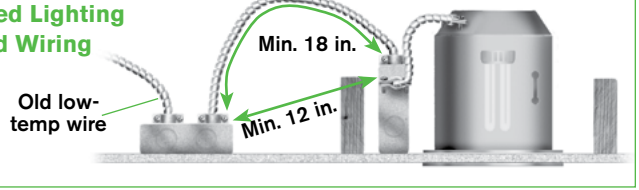
Lighting outlets and luminaires must be installed with no exposed live parts that could pose a shock hazard. The heating effect of luminaires must be considered, especially around thermal insulation. Lights rated "type IC" are suitable for insulated ceilings. See **p.32** for req'd locations. *Click **here** to view the UL Marking Guide for Luminaires.*

General	09 IRC	11 NEC
☐ All luminaires & lampholders listed	[3403.3]	{410.6}
☐ Exposed metal parts grounded EXC	[4003.3]	{410.42A}
• Incidental metal parts such as mounting screws	[4003.3]	{410.42A}
☐ Wet location luminaires L&L for wet location	[4003.9]	{410.10A}
☐ Damp location luminaires L&L for damp or wet location	[4003.9]	{410.10A}
☐ Screw shells for lampholders only–no adapters	[4003.4]	{410.90}

Recessed Lights	09 IRC	11 NEC
☐ Non-Type IC min 1/2 in. from combustibles	[4004.8]	{410.116A1}
☐ Non-Type IC min 3 in. from insulation	[4004.9]	{410.116B}
☐ Type IC OK in contact with combustible material	[4004.8]	{410.116A2}
☐ Type IC OK in contact with insulation	[4004.9]	{410.116B}
☐ Luminaires that req > 60°C wire must be marked	[n/a]	{410.74}
☐ Connect proper temp-rated wire to luminaire	[n/a]	{410.117A}
☐ Tap conductors to 60°C wire min 18 in. max 6 ft. F36	[n/a]	{410.117C}

FIG. 36

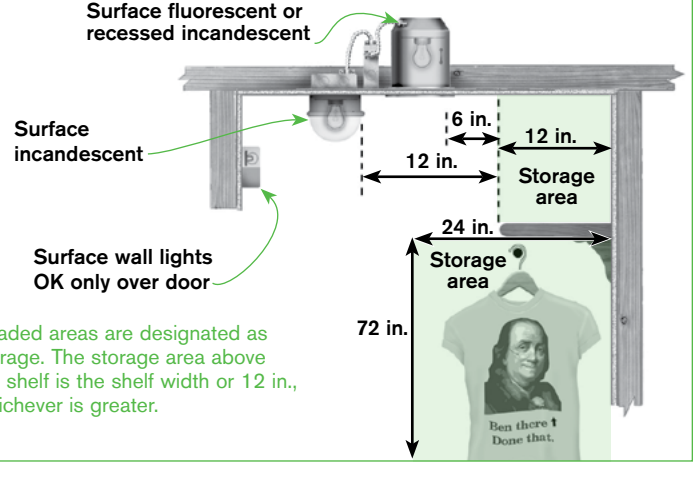
Recessed Lighting with Old Wiring



Closet Lights F37	09 IRC	11 NEC
☐ Incandescent bulbs req'd to be fully enclosed	[4003.12]	{410.16A1}
☐ Partially enclosed incandescent bulbs prohibited	[4003.12]	{410.16B}
☐ Surface-mounted only on ceiling or wall above door	[4003.12]	{410.16C1&2}
☐ Surface incandescents min 12 in. from storage	[4003.12]	{410.16C1}
☐ Surface fluorescents min 6 in. from storage	[4003.12]	{410.16C2}
☐ Recessed (wall or ceiling) min 6 in. from storage	[4003.12]	{410.16C3&4}
☐ Surface fluorescent or LED (light-emitting diode) OK in storage area if listed for same	[4003.12][35]	{410.16C5}

FIG. 37

Closet Lights

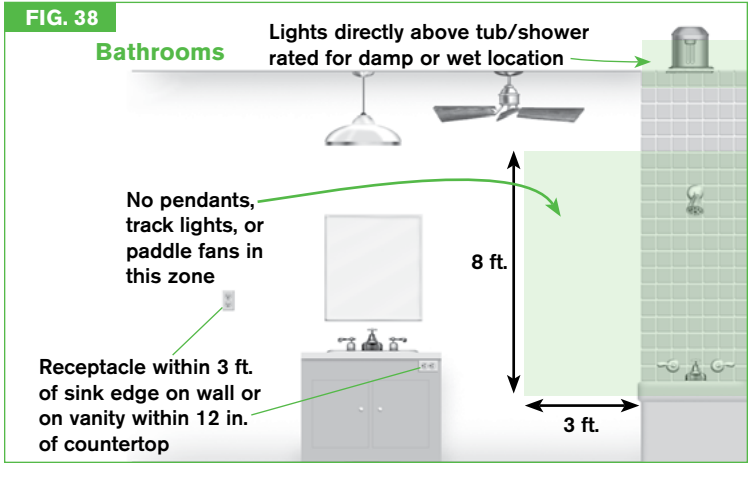


Shaded areas are designated as storage. The storage area above the shelf is the shelf width or 12 in., whichever is greater.

Track Lighting	09 IRC	11 NEC
☐ Branch circuit rating ≤ track rating	[4005.1]	{410.151B}
☐ Connected load ≤ track rating	[4005.3]	{410.151B}
☐ No track concealed, extended through walls or partitions, or in damp or wet locations	[4005.4]	{410.151C}
☐ Track must be securely fastened	[4005.5]	{410.154}
☐ Track must be grounded	[4005.6]	{410.155B}

Tub & Shower Areas F38	09 IRC	11 NEC
☐ No cord-connected or pendant luminaires, lighting track, or ceiling-suspended paddle fans 1st 8 ft. above tub rim or shower threshold & for zone extending 3 ft. outside	[4003.10]	{410.10D}
☐ Luminaires directly above tub & shower listed for damp locations (or wet locations if subject to shower spray)	[4003.10]	{410.10D}

FIG. 38



APPLIANCES

The term *appliances* is a generic term for standardized manufactured equipment that uses electricity (other than lighting). Whether portable or permanent, all appliances req a means of disconnecting the power source so the appliance can be safely serviced or replaced. The codes provide general rules for disconnecting appliances as well as specific rules for common built-in (fixed in place) appliances.

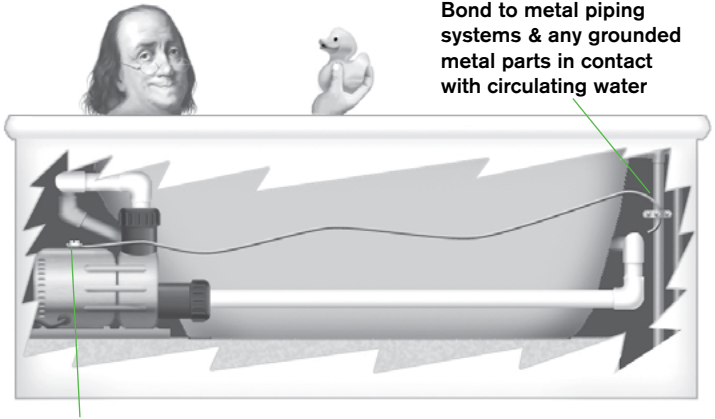
Disconnecting Devices	09 IRC	11 NEC
☐ All appliances req disconnecting means	[4101.5]	{422.30}
☐ Cord-connected appliances req attachment plug	[3909.4]	{410.7B}
☐ Accessible attachment plug OK as disconnect	[T4101.5]	{422.33A}
☐ Additional disconnect req'd if plug not accessible	[T4101.5]	{422.33A}
☐ Breaker alone OK for appliances <300VA or 1/8hp	[T4101.5]	{422.31A}
☐ In-sight switch or breaker req'd if ≥300VA or 1/8hp, or lockable breaker OK when not in sight F39	[T4101.5]	{422.31B}
☐ Breaker lockouts req permanent hasp F39	[T4101.5]	{422.31B}
☐ Unit switch opening all ungrounded conductors OK	[T4101.5]	{422.34}

FIG. 39

Hydromassage Tub (Whirlpool Bathtub)	09 IRC	11 NEC
☐ Readily-accessible GFCI protection req'd	[4209.1]	{680.71}
☐ Individual branch circuit req'd	[4209.1][36]	{680.71}
☐ Electrical equipment (pump motor) must be accessible	[4209.3]	{680.73}
☐ Disconnecting means req'd in sight of motor	[T4101.5]	{430.102B}
☐ Bond metal parts in contact with circulating water	[4209.4]	{680.74}
☐ Bonding conductor min solid 8 AWG Cu **F40**	[4209.4]	{680.74}
☐ Bond metal piping system to motor lug EXC **F40**	[4209.4][37]	{680.74}
• Double-insulated motor	[4209.4]	{680.74}
☐ Bonding conductor need not connect to panelboards	[4209.4]	{680.74}

FIG. 40

Hydromassage Tub (Whirlpool)



Kitchens	09 IRC	11 NEC
☐ Cords must be L&L (no NM cable)	[4101.3]	{422.16A}
☐ Garbage disposer cord min 18 in. max 36 in.	[T4101.3]	{422.16B1}
☐ Dishwasher or trash compactor cord min 3 ft. max 4 ft. measured from back	[T4101.3]	{422.16B2}
☐ Dishwasher & compactor receptacles in same space as appliance or in adjacent space	[n/a]	{422.16B2}
☐ Range hoods can be cord & plug connected if L&L for cord & on individual branch circuit	[4101.3]	{422.16B4}
☐ Range hood cords min 18 in. max 36 in.	[T4101.3]	{422.16B4}
☐ Cord & plug ovens & cooking units OK if L&L	[4101.3]	{422.16B3}

Central Furnace	09 IRC	11 NEC
☐ In-sight disconnect req'd	[T4101.5]	{422.31B&C}
*Refer to manu instructions for possible supplemental OCPD requirements **F41**.*		
☐ Lighting outlet switched at entry to equipment space	[3903.4]	{210.70A3}
☐ Central furnace must be on individual circuit EXC	[3703.1]	{422.12}
• Associated equipment (electrostatic filters, pumps, etc.)	[3703.1]	{422.12X1}
☐ 120V receptacle req'd within 25 ft. on same elevation	[3901.11]	{210.63}

FIG. 41

"SSU" Switch

A fused disconnect provides supplementary overcurrent protection & is sometimes a manufacturer's instruction.
An example might be a furnace requiring 15A overcurrent protection installed on a 20A circuit.

Electric Furnaces & Space Heaters	09 IRC	11 NEC
☐ Branch circuit 125% load (heat watts + motor)	[3702.10]	{424.3B}
☐ Disconnect in sight or lockable breaker F39	[T4101.5]	{424.19}
☐ Unit switch that opens all ungrounded conductors OK as disconnect for space heater with no motor > 1/8hp	[T4101.5]	{424.19C}

Central Vacuum	09 IRC	11 NEC
☐ Max 80% individual branch circuit rating, 50% of multi-outlet branch circuit rating	[3702.3]	{210.23A}
☐ Cord must have same ampacity as branch circuit	[n/a]	{422.15B}
☐ Bond all non-current-carrying metal parts	[3908.2]	{422.15C}

Water Heater	09 IRC	11 NEC
☐ In-sight or lockable breaker or switch OK F39	[T4101.5]	{422.31B}
☐ Breaker lockout hasp req'd to remain in place with lock removed F39	[T4101.5]	{422.31B}
☐ Bond hot, cold & gas pipes F13	[3609.7]	{250.104}

Outdoor De-icing & Snow Melting Equipment	09 IRC	11 NEC
☐ GFPE protection req'd for de-icing equipment	[4101.7]	{426.28}

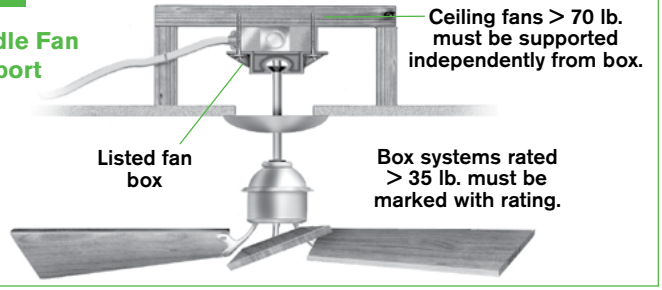
Some jurisdictions allow the GFPE function of an AFCI to meet this rule.

Air-Conditioning	09 IRC	11 NEC
☐ Wiring & OCPD per nameplate of L&L equipment	[3702.11]	{440.4B}
☐ Disconnect on or within sight of condenser F43	[T4101.5]	{440.14}
☐ Disconnect not OK on compressor access panel	[n/a]	{440.14}
☐ Working space req'd in front of disconnect F43	[3405.1]	{110.26A}
☐ Room AC plug disconnect OK if controls ≤6 ft. of floor	[n/a]	{440.63}
☐ Max cord length 120V = 10 ft., 240V = 6 ft.	[n/a]	{440.64}
☐ AFCI or leakage current detection interrupter (LCDI) in cord or plug for room AC units	[n/a]	{440.65}

*Click **here** to view the UL Marking Guide for Air Conditioning Equipment*

FIG. 42

Paddle Fan Support



Paddle Fans F42	09 IRC	11 NEC
☐ Listed box for fan support (no standard boxes)	[3905.9]	{314.27C}
☐ Listed fan boxes without weight marking OK to 35 lb.	[3905.9]	{314.27C}
☐ > 35 lb. & < 70 lb., fan box L&L for suitable weight	[3905.9]	{314.27C}
☐ Independent support for fans > 70 lb.	[3905.9]	{314.27C}

FIG. 43

Air-Conditioning Condenser

Smoke Alarms — 09 IRC

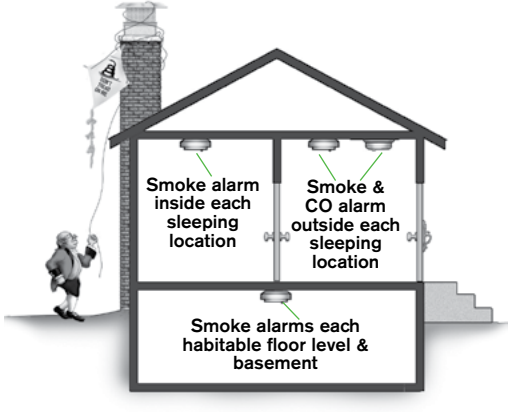
- ☐ NFPA 72 systems OK if permanent part of property _____ [314.2][38]
- ☐ Alarms req'd in each sleeping room & adjoining areas **F44** _____ [314.3]
- ☐ Req'd each story including basements & habitable attics **F44** _____ [314.3]
- ☐ Interconnect so activation of 1 alarm sets off all alarms _____ [314.3]
- ☐ Power from building wiring & battery backup EXC _____ [314.4]
  - Battery-only OK alterations or repairs with no access to wire path [314.4X2}

Carbon Monoxide Alarms — 09 IRC

- ☐ Req'd outside sleeping areas in dwellings with fuel-fired appliances or with attached garages **F44** _____ [315.1][39]
- ☐ Req'd when remodeling requiring permit is performed _____ [315.2][39]
- ☐ Install AMI & in compliance with UL 2034 _____ [315.3][39]

FIG. 44

Smoke & Carbon Monoxide Alarms



__T10__ is a "quick reference" guide to the maximum size breaker for a given size of wire. It is an abbreviated version of __T11–14__. Always consider if the conductors must be "derated" for ambient temperature, grouping, or the other factors on the next page. The sizes given for service entrance conductors apply for wires only with insulation types RHH, RHW, RHW-2, THHN, THHW, THW, THW-2, THWN, THWN-2, XHHW, XHHW-2, SE, USE, and USE-2.

TABLE 10 SIZING CONDUCTORS

Fuse or Breaker	Branch Circuits or Feeders Wire Size		Service Conductors (AWG)	
	Cu	Al	Cu	Al
15	14	12	n/a	n/a
20	12	10	n/a	n/a
30	10	8	n/a	n/a
40	8	6	n/a	n/a
50	6	4	n/a	n/a
60	6	3	n/a	n/a
70	4	2	n/a	n/a
80	3	1	n/a	n/a
90	2	1/0	n/a	n/a
100	2	1/0	4	2
110	1	1/0	3	1
125	1/0	1/0	2	1/0
150	1/0	2/0	1	2/0
200	3/0	4/0	2/0	4/0
225	4/0	250kcmil	3/0	250kcmil
400	500kcmil	700kcmil	400kcmil	600kcmil

AMPACITY OF WIRE

When wire overheats, its insulation begins to break down, and we say the wire has exceeded its ampacity. Protecting conductors and equipment from overheating and insulation failure is one of the main principles of electrical safety.

General	09 IRC	11 NEC
☐ Protect conductors at their ampacity EXC	[3705.5]	{240.4}
• Small conductors protected per note A in T11	[3705.5.3]	{240.4D}
• AC protected AMI	[3705.5.4]	{240.4G}
☐ OCPD for NM cable not to exceed 60°C ampacity	[3705.4.4]	{334.80}

Derating	09 IRC	11 NEC
☐ Apply temp-correction factor T12	[3705.2]	{310.15B2}
☐ Add correction for rooftop conduits per T13	[n/a]	{310.15B3c}
☐ Derate for > 3 current-carrying conductors in raceway or cables grouped without spacing > 24 in. in length	[3705.3]	{310.15B3a}
☐ Derate > 2 NM cables in caulked (fireblocked) hole	[3705.4.4]	{334.80}
☐ Derate > 2 NM cables installed without spacing in contact with thermal insulation	[3705.4.4][40]	{334.80}

*The first step in determining the allowable ampacity of a conductor is to look it up in **T11** based on the wire size & insulation type. The most common ratings of conductor insulation are 60°C, 75°C & 90°C. We use the 90°C column only for derating (temp. corrections), not for selection of the breaker or fuse. Conductors can be dual rated, with 75°C ratings in wet locations & 90°C ratings in dry locations, such as THWN/THHN.*

Breaker & equipment terminations have a temp. rating, typically 60°C and/or 75°C. The overall ampacity of a circuit is limited by the lowest-rated device or conductor in the circuit. The final choice of breaker is, therefore, usually limited by the temp. rating of the breaker terminals; & the insulation rating is used in the derating calculations. Nonmetallic sheathed cable & SE cable as interior wiring are restricted to a 60°C rating despite containing 90°C rated conductors.

TABLE 11 WIRE AMPACITIES [T3705.1] {310.15B16}

	60°C 140°F	75°C 167°F	90°C 194°F	60°C 140°F	75°C 167°F	90°C 194°F	
	INSULATION TYPES						
Cu (AWG)	TW UF	THHW THW THWN USE	THHN THHW THW-2 THWN2 USE-2	TW UF	XHHW USE	USE-2, XHHW-2	Al (AWG)
	Cu			Al			
14[A]	20	20	25	–	–	–	–
12[A]	25	25	30	20	20	25	12
10[A]	30	35	40	25	30	35	10
8	40	50	55	30	40	45	8
6	55	65	75	40	50	60	6
4	70	85	95	55	65	75	4
3	85	100	110	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	150	85	100	115	1
1/0	125	150	170	100	120	135	1/0
2/0	145	175	195	115	135	150	2/0
3/0	165	200	225	130	155	175	3/0
4/0	195	230	260	150	180	205	4/0
250	215	255	290	170	205	230	250

A. For Cu wire: max OCPD 30A for 10 AWG, 20A for 12 AWG & 15A for 14 AWG.
For Al wire, max OCPD 25A for 10 AWG & 20A for 12 AWG.

*In addition to size, material & insulation type, other factors must be considered. These are ambient temp. **T12**, the rate of heat dissipation into the ambient medium & the adjacent load-carrying conductors **T14**. Heat dissipates more readily to free air than to water, such as found in underground conduits. Thermal insulation traps heat, as do adjacent conductors when they are grouped together.*

*To determine the ambient temp. correction; apply the factors of **T12** to the ampacity listed in the appropriate column of **T11**. The heating effect of reflected sunlight must also be added to the temp. correction, per **T13**.*

TABLE 12 AMBIENT TEMPERATURE CORRECTION [T3705.2] & {310.15B2a}

Ambient Temp. °C	For Ambient Temp. > 30°C (86°F), Multiply the Allowable Ampacities in T11 by the Following Percentages:			Ambient Temp. °F
	60°C	75°C	90°C	
31–35	0.91	0.94	0.96	87–95
36–40	0.82	0.88	0.91	96–104
41–45	0.71	0.82	0.87	105–113
46–50	0.58	0.75	0.82	114–122
51–55	0.41	0.67	0.76	123–131
56–60	–	0.58	0.71	132–140
61–70	–	0.33	0.58	141–158

This table may have little effect on post-1984 90°C-based NM-B wiring. It can be important in remodels with older 60°C wire.

TABLE 13 TEMPERATURE ADJUSTMENT FOR CONDUITS EXPOSED TO SUNLIGHT ABOVE ROOFTOPS {T310.15B2c}

Distance between Roof & Conduit	Temp. Added to T12	
0 – 1/2 in.	33°C	60°F
> 1/2 in. – 3 1/2 in.	22°C	40°F
> 3 1/2 in. – 12 in.	17°C	30°F
> 12 in.	14°C	25°F

*Another consideration is conductor proximity, which traps heat & prevents heat dissipation when conductors are grouped. When there are more than 3 current-carrying conductors in a raceway, the derating factors of **T14** must be applied, in addition to any ambient temp. correction. These same derating factors also apply to a grouping of cables installed without spacing for a length of 24 in. or more & for groups >2 NM cables passing through an opening in wood framing that is fireblocked with thermal insulation, caulk, or foam & to NM cables installed without spacing & in contact with thermal insulation.*

TABLE 14 DERATING FOR CONDUCTOR PROXIMITY [T3705.3] {310.15B3a}

Number of Current-Carrying Wires	Ampacity Correction
4–6	80
7–9	70
10–20	50

With modern 90°C small conductors this table becomes significant when there are > 9 current-carrying conductors in a conduit or cable group, or when compounded by temp. corrections. Cables installed without spacing > 2 ft. are subject to the above derating. When newer 90°C wire is connected to older 60°C wire, such as pre-1984 NM, the ampacity of the lower-rated conductors applies to the entire circuit.

CABLE SYSTEMS

Cable systems are the most common residential wiring methods. Cables contain all conductors of the circuit inside a protective outer sheath of metal or plastic Starting with the 2005 edition, the NEC uses a parallel numbering system for rules pertaining to cables and raceways. See the common numbering system table (T24) on **p.63**. *Click **here** to view the UL Marking Guide for Wire and Cable.*

Cable Protection Indoors (NM, AC, MC, UF, SE)	**09 IRC**	**11 NEC**
☐ Bored holes & standoff clamps 1¼ in. setback F56	[3802.1]	{300.4A&D}
☐ Protect cables with 1/16 in. steel plate {or L&L plate} if closer than 1¼ in. to framing surfaces F45	[3802.1]	{300.4A&D}
☐ Cables min 1½ in. below sheet steel roof decks	[n/a]	{300.4E}[41]
☐ Provide guard strips within 6 ft. of attic scuttle (& up to 7 ft. high if attic has permanent access)	[3802.2.1]	{334.23}

FIG. 45

Nail-Plate Protection

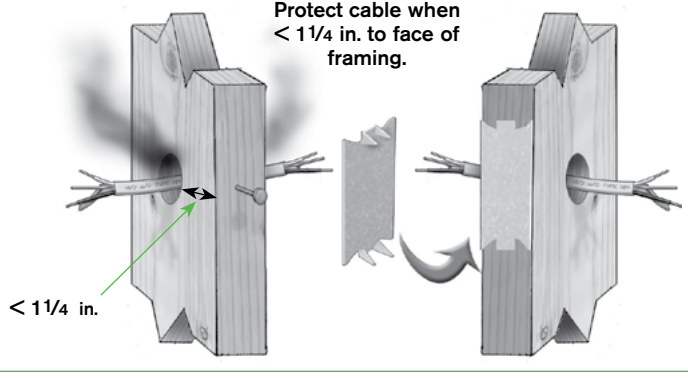


FIG. 46

Cable in an Attic with No Permanent Stair

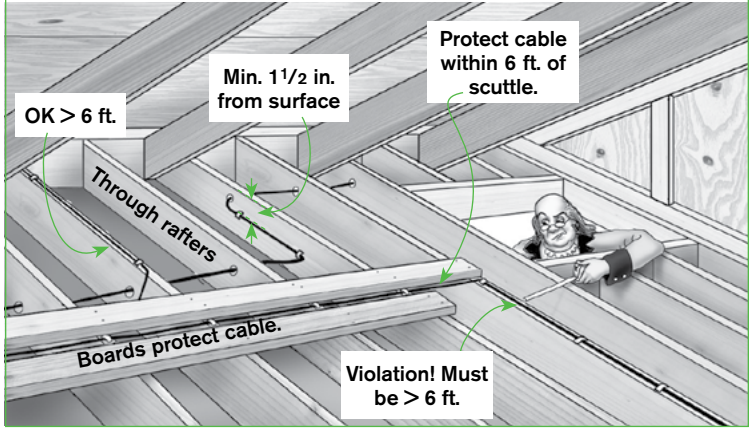
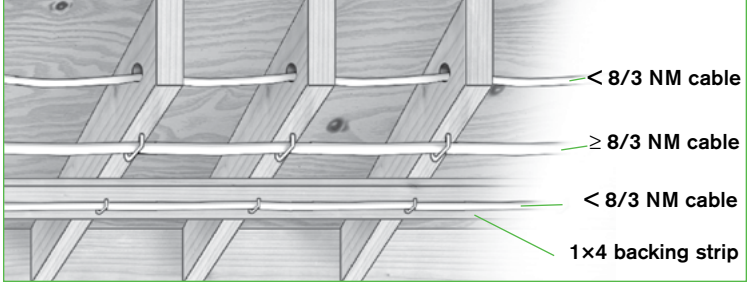


FIG. 47

Underfloor Cable in Basement or Crawl Space



NM–Nonmetallic Sheathed Cable F48

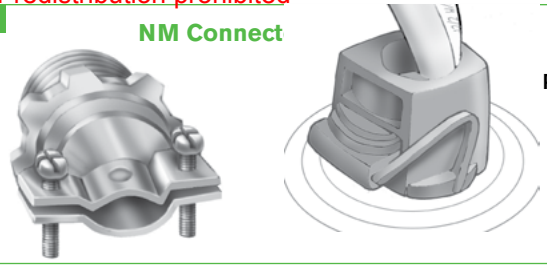
	09 IRC	11 NEC
☐ OK in dry locations only	[3801.4]	{334.12B4}
☐ Protect exposed cable from damage where necessary	[3802.3.2]	{334.15B}
☐ Listed grommets for holes through metal framing	[3802.1]	{300.4B1}
☐ OCPD selection based on 60° column T11	[3705.4.4]	{334.80}
☐ Derating & temp correction based on 90° rating	[3705.4.4]	{334.80}
☐ Derate > 2 NM cables in same caulked (fireblocked) hole	[3705.4.4]	{334.80}
☐ Derate > 2 NM cables installed without spacing in contact with thermal insulation	[3705.4.4][40]	{334.80}
☐ Secure to box with approved NM clamp EXC F49	[3905.3.2]	{314.17B&C}
• Single gang (2¼ × 4 in.) plastic box stapled within 8 in.	[3905.3.2]	{314.17CX}
☐ Min ¼ in. sheathing into plastic boxes	[3905.3.1]	{314.17C}
☐ Secure within 12 in. of box & max 4½ ft. intervals	[3802.1]	{334.30}
☐ Do not overdrive staples or staple flat cable on edge	[3802.1]	{334.30}
☐ Bends gradual (min 5× cable diameter)	[3802.5]	{334.24}
☐ Running board for small cable under joists F47	[3802.4]	{334.15C}

FIG. 48

NM – Nonmetallic-Sheathed Cable

FIG. 49

NM Connect

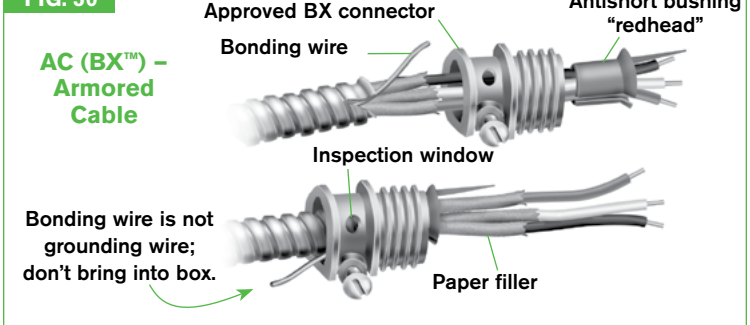


AC–Armored Cable (BX™) F50

	09 IRC	11 NEC
☐ Dry locations only	[3801.4]	{320.10}
☐ Secure within 12 in. of box & max 4½ ft. intervals EXC	[3802.1]	{320.30B}
• 2 ft. where flexibility needed (motors)	[3802.1]	{320.30D}
☐ Insulated (anti-short) bushing at terminations F50	[3802.1]	{320.40}
☐ Armor is EGC–don't bring bond wire into box F50	[3908.8]	{250.118}
☐ Underside of joists–secure at each joist	[n/a]	{320.15}

FIG. 50

AC (BX™) – Armored Cable



UF–Underground Feeder Cable F51	09 IRC	11 NEC
☐ Interior installation same rules as NM	[3801.4]	{340.10}
☐ May be buried in earth with cover per T1, F52	[3801.4]	{340.10}
☐ Protect where emerging from earth from 18 in. below grade to 8 ft. above F52	[3803.3]	{300.5D1}
☐ Single conductors in trench must be grouped	[3803.8]	{340.10}
☐ UV-resistant type OK exposed to sunlight	[3802.3.3]	{340.12}
☐ Not OK strung through air without support messenger	[3802.1]	{340.12}

FIG. 51

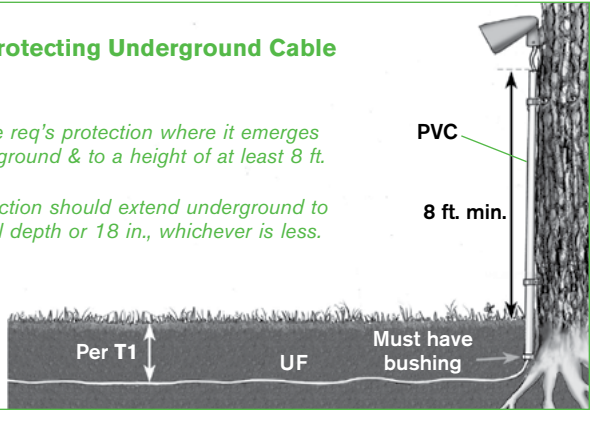
UF – Underground Feeder Cable

FIG. 52

Protecting Underground Cable

UF cable req's protection where it emerges from the ground & to a height of at least 8 ft.

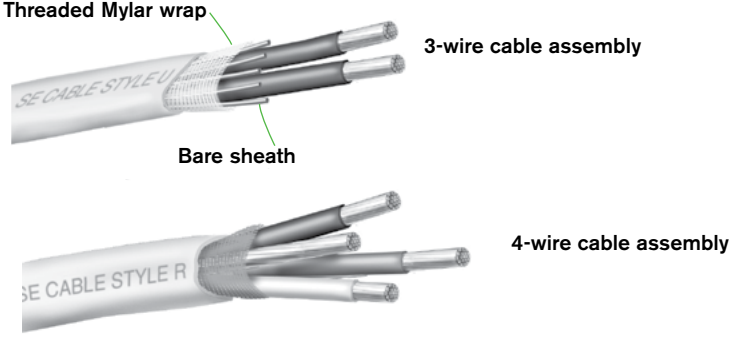
The protection should extend underground to the burial depth or 18 in., whichever is less.



SE–Service Entrance Cable F53 & USE–Underground Service Entrance Cable	09 IRC	11 NEC
☐ OK as service entrance conductor (see **p.8**)	[3801.4]	{338.10A}
☐ Type SE interior installation same rules as NM	[3802.1][42]	{338.10B4a}
☐ Type USE not OK for interior wiring	[3801.4]	{338.12B}
☐ SE not OK for direct burial, USE OK for direct burial	[3801.4]	[338.12B]
☐ Bare neutral OK for EGC of 240V branch circuit	[3801.4]	{338.10B2}
☐ Insulated neutral (type SE-R) req'd for feeders except to separate existing building with no other continuous metal path (see **p.10,22**)	[3801.4]	{338.10B2X}
☐ Bends gradual (min 5× cable diameter)	[3802.5]	{338.24}

FIG. 53

SE Cable



MC–Metal-Clad Cable F54,55

	09 IRC	11 NEC
☐ Support or secure at max 6 ft. intervals	[3802.1]	{330.30B&C}
☐ Secure within 12 in. of box or other termination EXC	[3802.1]	{330.30B}
• Unsupported whip ≤ 6 ft. to luminaire in accessible ceiling	[3802.1]	{330.30D}
• Where fished	[n/a]	{330.30D}
☐ Bends gradual (min 7× interlocked armor diameter)	[3802.5]	{330.24}

FIG. 54

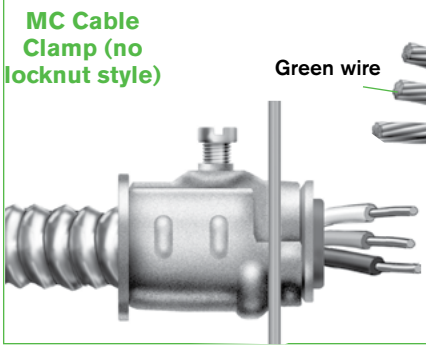


FIG. 55

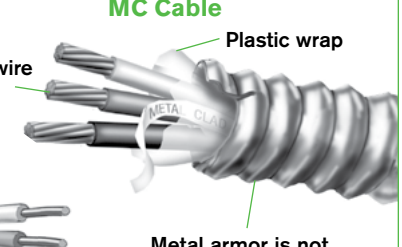


FIG. 56

Stand-Off Clamp

Used to maintain clearances to stud or joist edge

VOLTAGE DROP

When laying out wiring, consider the voltage drop caused by long runs of wire. Fine-print note #4 of 210.19 of the NEC recommends (though it does not req) a maximum voltage drop of 3% on branch circuits and a 5% overall voltage drop, including the feeders. Excessive voltage drop can cause problems in connected equipment and adds to the monthly utility costs. One way to overcome a voltage drop problem is to use larger wire than the minimum size and to make sure that all connections are tight. Voltage drop increases proportionately to the load on the circuit. Adding more than the minimum number of circuits helps prevent individual circuits from overloading. The added cost of more wiring will pay for itself over time in reduced utility costs and greater equipment efficiency.

In the table below, the distances shown are the maximum length of cable to stay within a 3% branch circuit voltage drop at 80% of the allowable load on the circuit. Multiwire circuits (**p.23**) act as 240V circuits for voltage drop to the extent that the load on them is balanced. When only one side of the multiwire circuit has a load, the voltage drop is the same as for any other 120V circuit.

TABLE 15 CABLE LENGTH TO LIMIT VOLTAGE DROP TO 3%

Wire Size (AWG)	Cu Distance (ft.)		Al Distance (ft.)	
	120V	240V	120V	240V
14	50	100	N/A	N/A
12	60	120	36	72
10	64	128	38	76
8	76	152	46	92
6	94	188	57	114

Based on 80% circuit loading for normal OCPD.

RACEWAYS

Raceways are complete systems of conduit or tubing through which conductors are installed. In the NEC numbering system, all articles pertaining to raceways have a parallel numbering system so the portion after the article number is the same for all types. Article numbers are the first 3 digits before the period inside each section number. See the common numbering system table **T24** on **p.63**.

General	09 IRC	11 NEC
☐ Conductors in raceways stranded if ≥ 8 AWG	[3406.4]	{310.3}
☐ Wet-rated conductors req'd in raceways above grade in wet locations	[3802.7][43]	{300.9}
☐ Raceway req to be complete before to wiring EXC	[3904.5]	{300.18A}
• Short sections of raceway for cable protection	[3904.5X]	{300.18AX}
☐ Bends req'd to have even radius–no kinks	[3802.5]	{***.24}
☐ 360° max bends between pull points **F57**	[3802.1]	{***.26}
☐ Raceway must be reamed after cutting	[3802.1]	{***.28}
☐ Plastic bushing/liner req'd if conductors ≥4 AWG	[3906.1.1]	{300.4G}
☐ Box & conduit body covers must remain accessible	[3905.11]	{314.29}
☐ No plastic boxes with metal cables or raceways unless bonded through box	[3905.3X]	{314.3X}
☐ No splicing in conduit bodies except conduit bodies with sufficient volume per marking	[3905.13.3.1]	{314.16C2}
☐ Max 40% fill if > 2 conductors **T21, 22**	[3904.6]	{***.22}
☐ Derate conductors as needed **T11–14**	[3705.2&3]	{310.15B2a}

EMT–Electrical Metallic Tubing **F58**	09 IRC	11 NEC
☐ Direct burial or embedment not OK	[3801.4]	{358.10B}
☐ In wet locations use L&L wet fittings	[3905.12]	{358.42}
☐ Secure in place max 10 ft. intervals & 3 ft. from each box, conduit body or cabinet	[3802.1]	{358.30A}

EMT–Electrical Metallic Tubing (cont.) **F58**	09 IRC	11 NEC
☐ Horizontal runs supported by holes in framing OK if securely fastened within 3 ft. of box, conduit body, or cabinet	[3802.1]	{358.30B}
☐ Not OK as support for boxes, but OK for conduit bodies	[n/a]	{358.12}

FIG. 57

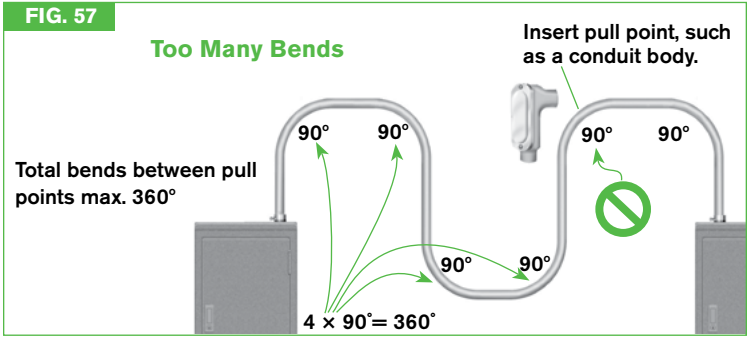
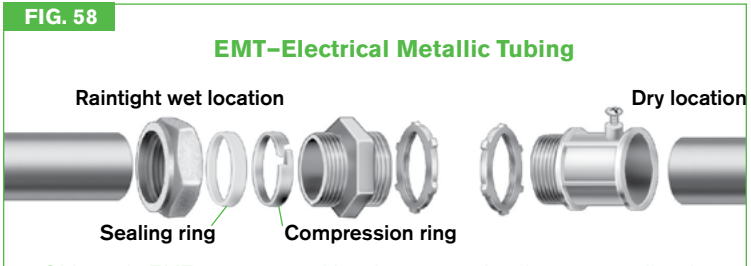


FIG. 58



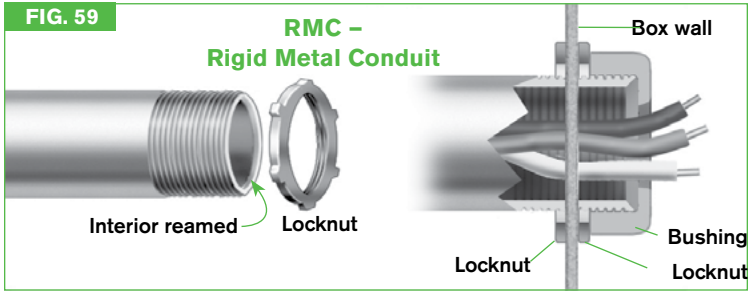
Older style EMT connectors with only compression ring were not listed.

RMC–Rigid Metal Conduit F59

	09 IRC	11 NEC
☐ Galvanized RMC typically sufficient corrosion protection for direct burial or embedment	[3801.4]	{344.10B}
☐ Coat buried field cut threads with L&L compound	[3801.4]	{300.6A}
☐ Provide bushing or fitting at box connection F59	[3802.1]	{344.46}
☐ No threadless connectors on threaded conduit ends	[n/a]	{344.42}
☐ Secure in place within 3 ft. of termination	[3802.1]	{344.30A}
☐ Horizontal support spacing max 10 ft.	[3802.1]	{344.30B}

FIG. 59

RMC – Rigid Metal Conduit

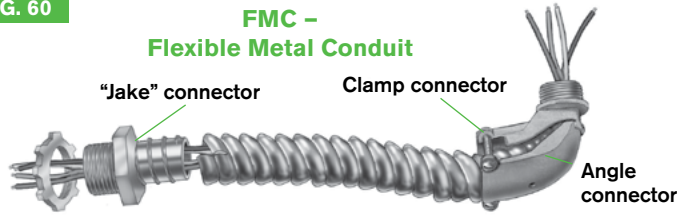


FMC–Flexible Metal Conduit ("Greenfield") F60

	09 IRC	11 NEC
☐ Dry locations only	[3801.4][44]	{348.12}
☐ Support max spacing 4 1/2 ft. & 12 in. from boxes EXC	[3802.1]	{348.30A}
• Lighting whip in accessible ceiling OK to 6 ft. OR	[3802.1]	{348.30AX4}
• 36 in. where flexibility is needed	[3802.1]	{348.30AX1}
☐ Armor is OK as EGC if fittings listed, circuit ≤ 20A, no flexibility needed & ≤ 6 ft. long	[3908.8.1]	{250.118}
☐ Angle connections may not be concealed F60	[n/a]	{348.42}

FIG. 60

FMC – Flexible Metal Conduit

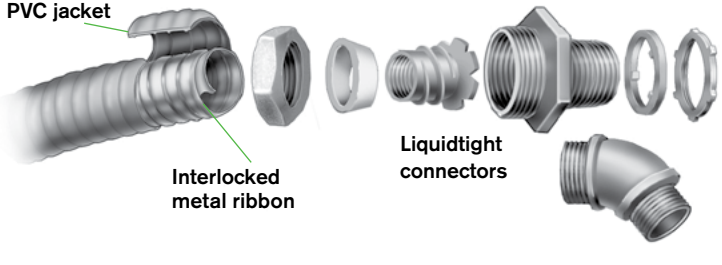


LFMC–Liquidtight Flexible Metal Conduit F61

	09 IRC	11 NEC
☐ OK for wet locations	[3801.4]	{350.10}
☐ OK for direct burial if L&L	[3801.4]	{350.10}
☐ OK as EGC up to 6 ft. if fittings listed, circuit ≤20A or ≤60A for sizes 3/4–1 1/4 in. & no flexibility needed	[3908.8.1]	{250.118}
☐ Support max spacing 4 1/2 ft. & 12 in. from boxes EXC	[3802.1]	{350.30A}
• 36 in. where flexibility is needed	[3802.1]	{350.30AX2}

FIG. 61

LFMC – Liquidtight Flexible Metal Conduit



LFNC–Liquidtight Flexible Nonmetallic Conduit F62

	09 IRC	11 NEC
☐ OK in lengths > 6 ft. if secured every 3 ft.	[n/a]	{356.10}
☐ Securing or supporting not req'd up to 3 ft. for motors	[3802.1]	{356.30}
☐ OK for direct burial or encasement when L&L	[3801.4]	{356.10}
☐ EGC req'd	[3908.4]	{250.4A5}

PVC–Rigid Polyvinyl Chloride Conduit F63

	09 IRC	11 NEC
☐ Burial depth per T1	[3803.1]	{300.5A}
☐ Support to prevent sags per T16 & within 3 ft. of box	[3802.1]	{352.30}
☐ Expansion joints req'd if subject to ≥ 1/4 in. shrinkage	[n/a]	{352.44}
☐ Not OK for support of luminaires or boxes	[n/a]	{352.12B}
☐ Not permitted in environments > 50°C (122°F)	[n/a]	{352.12D}

ENT–Electrical Nonmetallic Tubing F64

	09 IRC	11 NEC
☐ OK embedded in concrete with approved fittings	[3801.4]	{362.10}
☐ Not OK in environments > 50°C (122°F)	[n/a]	{362.12}
☐ Not OK for direct earth burial	[3801.4]	{362.12}
☐ Must be identified as sunlight resistant if outdoors	[3801.4]	{362.12}
☐ Secure or support every 3 ft. EXC	[3802.1]	{362.30A&B}
• 6 ft. unsupported OK to luminaires in accessible ceiling	[3802.1]	{362.30AX2}

FIG. 62

LFNC–Liquidtight Flexible Nonmetallic Conduit

FIG. 63

PVC 80 Conduit & Connector

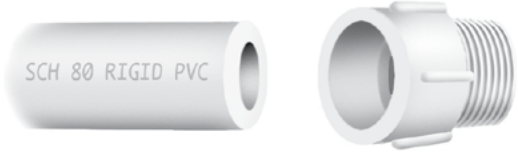


FIG. 64

ENT & Connector

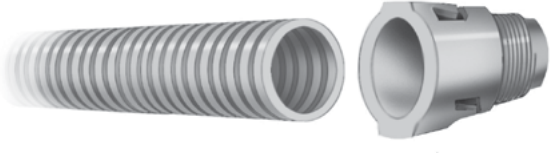


TABLE 16	PVC CONDUIT SUPPORT MAX. SPACING [T3802.1] {T352.30}	
Conduit Trade Size	2009 IRC	2011 NEC
1/2 in.–1 in.	3 ft.	3 ft.
1 1/4 in.–2 in.	5 ft.	5 ft.
2 1/2 in.–3 in.	5 ft.	6 ft.
3 1/2 in.–5 in.	5 ft.	7 ft.

FILL TABLES FOR ALL CONDUCTORS OF THE SAME SIZE

TABLE 17
EMT FILL
[3904.6(1)] {ANNEX T C.1}

Size (AWG)	Number of Conductors in THHN, THWN					
•	½	¾	1	1¼	1½	2
14	12	22	35	61	84	138
12	9	16	26	45	61	101
10	5	10	16	28	38	63
8	3	6	9	16	22	36
6	2	4	7	12	16	26
4	1	2	4	7	10	16
3	1	1	3	6	8	13
2	1	1	3	5	7	11
1	1	1	1	4	5	8
1/0	1	1	1	3	4	7
2/0	0	1	1	2	3	6
3/0	0	1	1	1	3	5
4/0	0	1	1	1	2	4
250	0	0	1	1	1	3

TABLE 18
EMT FILL
{ANNEX T C.1(A)}

Size (AWG)	Number of Conductors in XHHW (Compact Stranding)					
•	½	¾	1	1¼	1½	2
14	–	–	–	–	–	–
12	–	–	–	–	–	–
10	–	–	–	–	–	–
8	3	5	8	15	20	34
6	1	4	6	11	15	25
4	1	3	4	8	11	18
3	–	–	–	–	–	–
2	1	1	3	6	8	13
1	1	1	2	4	6	10
1/0	1	1	1	3	5	8
2/0	1	1	1	3	4	7
3/0	0	1	1	2	3	6
4/0	0	1	1	1	3	5
250	0	1	1	1	2	4

TABLE 19
SCHEDULE 80 PVC FILL
(3904.6(9)] {ANNEX T C.9}

Size (AWG)	Number of Conductors in THHN, THWN					
•	½	¾	1	1¼	1½	2
14	9	17	28	51	70	118
12	6	12	20	37	51	86
10	4	7	13	23	32	54
8	2	4	7	13	18	31
6	1	3	5	9	13	22
4	1	1	3	6	8	14
3	1	1	3	5	7	12
2	1	1	2	4	6	10
1	0	1	1	3	4	7
1/0	0	1	1	2	3	6
2/0	0	1	1	1	3	5
3/0	0	1	1	1	2	4
4/0	0	0	1	1	1	3
250	0	0	1	1	1	3

TABLE 20
SCHEDULE 80 PVC FILL
{ANNEX T C.9(A)}

Size (AWG)	Number of Conductors in XHHW (Compact Stranding)					
•	½	¾	1	1¼	1½	2
14	–	–	–	–	–	–
12	–	–	–	–	–	–
10	–	–	–	–	–	–
8	1	4	7	12	17	29
6	1	3	5	9	13	21
4	1	1	3	6	9	15
3	–	–	–	–	–	–
2	1	1	2	5	6	11
1	1	1	1	3	5	8
1/0	0	1	1	3	4	7
2/0	0	1	1	2	3	6
3/0	0	1	1	1	3	5
4/0	0	0	1	1	2	4
250	0	0	1	1	1	3

Conduit Fill Calculations

When all conductors are the same size, use T17–20. When different sized conductors are used, use T21 to find the wire areas, add them up, and use T22 to find the minimum size conduit. Example: 3 2 AWG THHN + 3 8 AWG XHHW in FMC: (3 × 0.1158) + (3 × 0.0394) = 0.4656, and the next greater size in the 40% column is 0.511. Therefore, a 1¼ in. FMC conduit meets code. When conductor calculation is close to conduit table values, one size larger is recommended.

TABLE 21 SQ. IN. AREA OF CONDUCTORS (BASED ON NEC T5 CHAPTER 9)

	14	12	10	8	6	4	2	1	1/0	2/0	3/0	4/0	250
TW	.0139	.0181	.0243	.0437	.0726	.0973	.1333	.1901	.2223	.2624	.3117	.3718	.4596
THHN	.0097	.0133	.0211	.0366	.0507	.0824	.1158	.1562	.1855	.2223	.2679	.3237	.3970
XHHW[1]	–	–	–	.0394	.0530	.0730	.1017	.1352	.1590	.1885	.2290	.2733	.3421

1. Based on compact-stranded conductors {Annex C, table 5A}

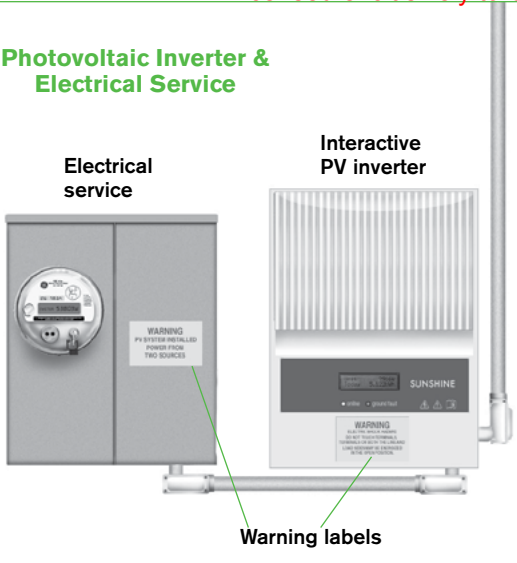
TABLE 22 CONDUIT & TUBING FILL (BASED ON NEC T4 CHAPTER 9)

Trade Size	Internal Diameter								2 wire sq. in. Fill 31%								> 2 Wire sq. in. Fill 40%							
	EMT	FMC	LFMC	LFNMC[1]	IMC	RMC	PVC80	PVC40	EMT	FMC	LFMC	LFNMC[1]	IMC	RMC	PVC80	PVC40	EMT	FMC	LFMC	LFNMC[1]	IMC	RMC	PVC80	PVC40
⅜	–	0.384	0.494	0.495	–	–	–	–	–	0.036	0.059	0.060	–	–	–	–	–	0.046	0.077	0.077	–	–	–	–
½	0.622	0.635	0.632	0.630	0.660	0.632	0.526	0.602	0.094	0.098	0.097	0.097	0.106	0.097	0.067	0.088	0.122	0.127	0.125	0.125	0.137	0.125	0.087	0.114
¾	0.824	0.824	0.830	0.825	0.864	0.836	0.722	0.804	0.165	0.165	0.168	0.166	0.182	0.170	0.127	0.157	0.213	0.213	0.216	0.214	0.235	0.220	0.164	0.203
1	1.049	1.020	1.054	1.043	1.105	1.063	0.936	1.029	0.268	0.253	0.270	0.265	0.297	0.275	0.213	0.258	0.346	0.327	0.349	0.342	0.384	0.355	0.275	0.333
1¼	1.380	1.275	1.395	1.383	1.448	1.394	1.255	1.360	0.464	0.396	0.474	0.466	0.510	0.473	0.383	0.450	0.598	0.511	0.611	0.601	0.659	0.610	0.495	0.581
1½	1.610	1.538	1.588	1.603	1.683	1.624	1.476	1.590	0.631	0.576	0.614	0.626	0.690	0.642	0.530	0.616	0..814	0.743	0.792	0.807	0.890	0.829	0.684	0.794
2	2.067	2.040	2.033	2.063	2.150	2.083	1.913	2.047	1.040	1.013	1.006	1.036	1.125	1.056	0.891	1.020	1.342	1.307	1.298	1.337	1.452	1.363	1.150	1.316
2½	2.731	2.500	2.493	–	2.557	2.489	2.290	2.445	1.816	1.522	1.513	–	1.592	1.508	1.277	1.455	2.343	1.963	1.953	–	2.054	1.946	1.647	1.878
3	3.356	3.000	3.085	–	3.176	3.090	2.864	3.042	2.742	2.191	2.317	–	2.456	2.325	1.997	2.253	3.538	2.827	2.990	–	3.169	3.000	2.577	2.907
3½	3.834	3.500	3.520	–	3.671	3.570	3.326	3.521	3.579	2.983	3.017	–	3.281	3.103	2.693	3.018	4.618	3.848	3.893	–	4.234	4.004	3.475	3.895
4	4.334	4.000	4.020	–	4.166	4.050	3.786	3.998	4.573	3.896	3.935	–	4.226	3.994	3.490	3.892	5.901	5.027	5.077	–	5.452	5.153	4.503	5.022

1. Dimensions for LFNMC are for type A; type B has an interior diameter identical to LFMC.

FIG. 65

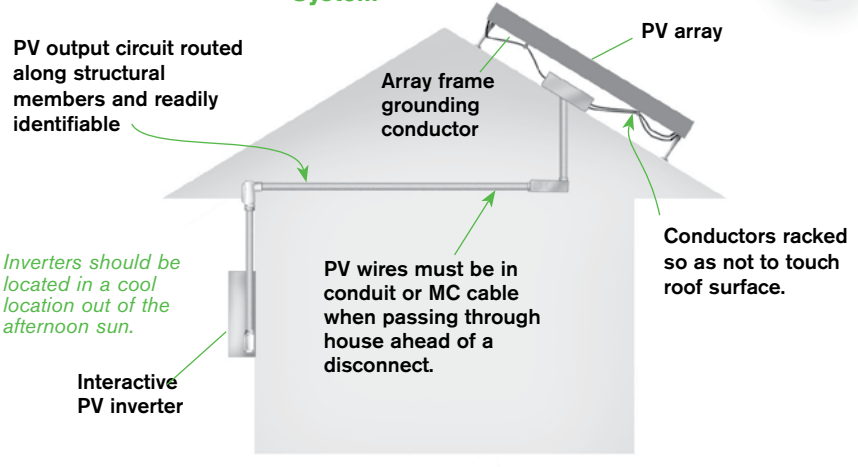
Photovoltaic Inverter & Electrical Service



Modern inverters with integral AC & DC disconnects eliminate the need for multiple components.

FIG. 66

Photovoltaic System



Structural issues and wind uplift must be considered; several manufacturers now make rack support systems specifically for PV. The NEC requirements for lightning protection are minimal & lightning can severely damage PV equipment. Surge suppressors can be permanently installed for component protection.

PHOTOVOLTAICS

In most states, the utility will rebate a portion of the cost of a PV system. Time-of-use and net metering can reduce or eliminate monthly utility costs. The quality and efficiency of PV equipment have improved greatly in the last few years. What once req'd numerous separate components is often integrated into a single piece of equipment. Contact the utility and building department before beginning any project involving renewable energy sources. (note- the IRC does not include PV.)

Definitions

Array: An assembly of panels that forms the power-producing unit **F66**.

Combiner: The location where parallel PV source circuits are connected to create a PV output circuit.

Hybrid system: A system with multiple power sources (not including the utility or batteries). An example would be a system with a generator & a PV source.

Interactive system: A solar PV system that operates in parallel to the utility.

Inverter: Equipment that converts the DC current & voltage of a PV output circuit to an AC waveform **F65**.

Inverter output circuit: The AC conductors from an inverter to an AC panelboard or service **F65**.

Module: A group of PV cells connected together & encapsulated in an environmentally protective laminate–usually tempered glass–to generate DC power when exposed to the sun.

Panel: A group of modules preassembled onto a common frame & designed to be field installed.

PV output circuit: Conductors between the PV source circuits & the inverter **F66**.

PV source circuits: Circuits between modules & circuits from modules to the common connection points (combiners) of the DC system.

Stand-alone system: Solar PV system supplying power independent of the utility.

General — 11 NEC

- ☐ Inverters, modules, panels, source circuit combiners L&L for PV ____ {690.4D}
- ☐ PV req'd to be installed by only qualified persons _____ {690.4E}[45]
- ☐ Max voltage = sum of rated open-circuit voltage of series connected modules times correction factors for cold temp **F67** _____ {690.7A}
- ☐ All power sources req disconnects _____ {690.15}
- ☐ DC disconnect req'd for ungrounded conductors **F65** _____ {690.13}
- ☐ PV output circuits req in-sight disconnect_____ {690.16B}
- ☐ Disconnect for ungrounded conductors must be readily accessible switch or breaker with no exposed live parts **F65**_____{690.17}
- ☐ Warning req'd at DC disconnect if all terminals hot while open **F65** {690.17}
- ☐ Rated max currents & voltages labeled on DC disconnect _____ {690.53}
- ☐ No disconnect on grounded conductor if it would be left energized {690.13}
- ☐ PV disconnecting means req'd to be on outside or inside nearest point of entrance of conductors EXC_____ {690.14(C1}
  Source circuits through interior OK in metal conduit **F66** _____ {690.31E}
- ☐ AC disconnects energized from 2 directions req warning label **F65** _{690.17}
- ☐ Backfed breakers not req'd to be secured in place EXC_____ {705.12D6}
  - Stand-alone systems (non-utility-interactive)_____ {609.10E}

Arrays & Inverters — 11 NEC

- ☐ Req'd markings on modules: polarity, max OCPD rating for module protection, open-circuit voltage, operating voltage, max system voltage, operating current, short-circuit current & max power _____ {690.51}
- ☐ PV circuits may not share raceways with non-PV systems EXC____ {690.4B}
  - OK with barriers, tagging & grouping _____ {690.4B}
- ☐ DC ground-fault protection (DC GFP) req'd_____{690.5}
- ☐ Inverter listed as interactive if used in interactive system_____ {690.60}
- ☐ DC arc-fault protection req'd systems > 80V _____ {690.11}[46]
- ☐ Interactive systems to automatically disconnect in grid outage EXC {690.61}
  - OK to feed subpanel isolated from service by transfer switch _____ {690.61}

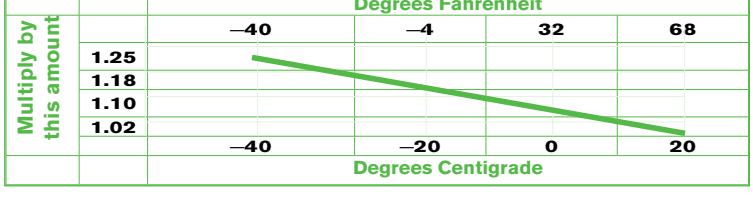
Grounding — 11 NEC

- ☐ Module frames & all metal parts must be grounded {690.43A}
- ☐ Size EGCs of PV output circuit per T6 & min 14 AWG {690.45}
- ☐ EGCs must be run in same raceway as PV array circuit conductors {690.43F}
- ☐ Bond ground-mounted array structures {690.43C}
- ☐ DC 2-wire system > 50V must have grounded conductor {690.41}
- ☐ Same conductor can perform DC grounding, AC grounding & bonding between AC & DC systems F65,66 {690.47C3}
- ☐ When grounded conductor bonded to EGC internal within DC GFP device, bond not to be duplicated with an external connection {690.42X}

Overcurrent Protection & Wiring — 11 NEC

- ☐ Single OCPD OK for series-connected string {690.9E}
- ☐ Sum of PV & main breakers not > 120% of panel rating {705.12D2}
- ☐ Source circuit currents = 125% × sum of parallel circuit currents {690.8A1}
- ☐ Locate PV breaker opposite end of bus from main or feeder input {705.12D7}
- ☐ Apply label warning against moving PV breaker {705.12D7}
- ☐ Size conductors for 125% of max PV source short circuit currents {690.8B1}
- ☐ Max allowable voltage in SFD 600V {690.7C}
- ☐ Consider high ambient temp (use 90°C wire) {690.31}
- ☐ No multiwire or 240V circuits in panels with 120V supply {690.10C}
- ☐ Single conductor cables type USE or L&L as PV wire in exposed outdoor source circuits (behind modules) {690.31B}

FIG. 67 Voltage Correction Factors {NEC T690.7}



SWIMMING POOL

Electricity and water can be a lethal mix. Precautions must be taken for shock hazard protection and to prevent corrosion of electrical equipment. Bonding is important to eliminate voltage gradients in the pool area. For GFCI requirements, see **p.29**. *Click **here** to view the UL Marking Guide for Pool & Spa Equipment.*

Overhead Conductor Clearances — 09 IRC — 11 NEC

- ☐ 22½ ft. clearance in any direction from water [T4203.5] {680.8A}
- ☐ 14½ ft. in any direction from diving platform [T4203.5] {680.8A}

Underground Wiring — 09 IRC — 11 NEC

- ☐ Non-pool underground wiring min 5 ft. from pool EXC [4203.7] {680.10}
  - • If space limited, RMC, IMC, or PVC systems OK [4203.7] {680.10}
- ☐ Cover depth min 6 in. for RMC or IMC, 18 in. for PVC [T4203.7] {680.10}

Feeders to Pool Panelboards — 09 IRC — 11 NEC

- ☐ New feeder req's RMC, IMC, LFNMC, or PVC EXC [T4202.1] {680.25A}
  - • EMT OK on or within buildings [T4202.1] {680.25A}
- ☐ Raceway req's min 12 AWG insulated EGC EXC [T4202.1] {680.25B}
  - • Existing FMC or cable with EGC OK [4205.6X] {680.25AX}

Pool Pump Motors — 09 IRC — 11 NEC

- ☐ RMC, IMC, PVC, or listed MC OK for branch circuit [T4202.1] {680.21A1}
- ☐ Branch circuits in AC, FMC, or NM only within building [T4202.1] {680.21A1}
- ☐ EMT branch circuit OK on or within building [T4202.1] {680.21A2}
- ☐ Flexible connection OK in LFMC or LFNMC [T4202.1] {680.21A3}
- ☐ Cord & plug connected motors OK with cord ≤ 3 ft. [4202.2] {680.21A4}
- ☐ Cords req EGC min 12 AWG & per T6 [4202.2] {680.7B}

Underwater Wet-Niche Lighting F68 — 09 IRC — 11 NEC

- ☐ Min 18 in. below water level [4206.4.2] {680.23A5}
- ☐ Luminaire bonded & secured to shell with locking device [4206.5] {680.23B5}
- ☐ Luminaire must req tool for removal [4206.5] {680.23B5}

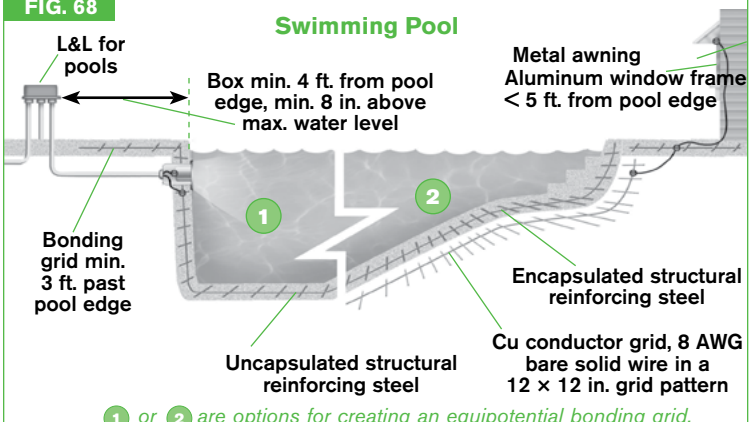
Underwater Wet-Niche Lighting (cont.) F68	09 IRC	11 NEC
☐ Low-voltage transformers req L&L for pool	[4206.1]	{680.23A2}
☐ Conductors from load side of GFCI or transformer not in same raceway or box as non-GFCI wires	[4206.3]	{680.23F3}
☐ Forming shell req's bonding terminal if PVC conduit	[4206.5]	[680.23B1]
☐ Nonmetallic conduit req's 8 AWG bonding conductor	[4205.3]	{680.23B2}
☐ Bonding conductor insulated & potted in forming shell	[4205.3]	{680.23B2}
☐ Min 16 AWG EGC in cord to wet-niche fixture	[4205.4]	{680.23B3}
☐ EGC connections on terminals only–no splices	[4205.2]	{680.23F2}

Equipotential Bonding F68	09 IRC	11 NEC
☐ Purpose of bonding is to reduce voltage gradients	[4204.1]	{680.26A}
☐ Bond metal parts of pool structure, ladders, equipment, fences & screens or structures < 5 ft. from pool EXC	[4204.2]	{680.26B}[47]
• Small isolated parts < 4 in. or < 1 in. into pool structure	[4204.2]	{680.26B5}
☐ Bond motors except listed & double-insulated type	[4204.2]	{680.26B6X}
☐ Provide bond wire to area of double-insulated motor	[4204.2]	{680.26B6}
☐ Bonding conductor min #8 solid Cu	[4204.2]	{680.26B}
☐ Unencapsulated steel shell req'd to be bonded	[4204.2]	{680.26B1}
☐ Cu conductor grid req'd if pool shell steel encapsulated in nonconductive compounds (coated rebar)	[4204.2][48]	{680.26B1}
☐ Cu conductor grid req's 8 AWG Cu in 12 ×12 in. pattern, conforming to contour of pool & deck, ≤ 6 in. from outer contour of pool shell, all conductors bonded at crossings	[4204.2][48]	{680.26B1}
☐ Perimeter surfaces for 3 ft. beyond pool req equipotential bonding with steel wire or reinforcement	[4204.2][48]	{680.26B2b}
☐ Connect perimeter to unencapsulated steel pool shell or Cu conductor grid at min 4 points	[4204.2][48]	{680.26B2}
☐ Min 9 sq. in. bonded metal contacting pool water	[4204.3][49]	{680.26C}

Receptacles (see p.29 for GFCI requirements)	09 IRC	11 NEC
☐ Min 1 receptacle ≥ 6 ft. & ≤ 20 ft. from pool walls	[4203.1.2]	{680.22A3}
☐ Pump motor receptacles not < 10 ft. from pool wall EXC • 6 ft. OK for single-receptacle twist-lock types	[4203.1.1]	{680.22A1}
☐ Dimensions include distance around barriers without penetrating a floor, wall, doorway, or window opening	[4203.1]	{680.22A5}

Lighting Outlets & Luminaires	09 IRC	11 NEC
☐ Outdoors ≥ 5 ft. from pool edge unless 12 ft. above	[4203.4.1]	{680.22C1}
☐ Indoors ≥ 7 ft. 6 in. above water if enclosed & GFCI	[4203.4.2]	{680.22C2}
☐ Existing lighting OK if GFCI & ≥ 5 ft. from pool edge & ≥ 5 ft. high	[4203.4.3]	{680.22C3}
☐ Switches min 5 ft. from pool edge or separated by barrier	[4203.2]	{680.22D}

FIG. 68



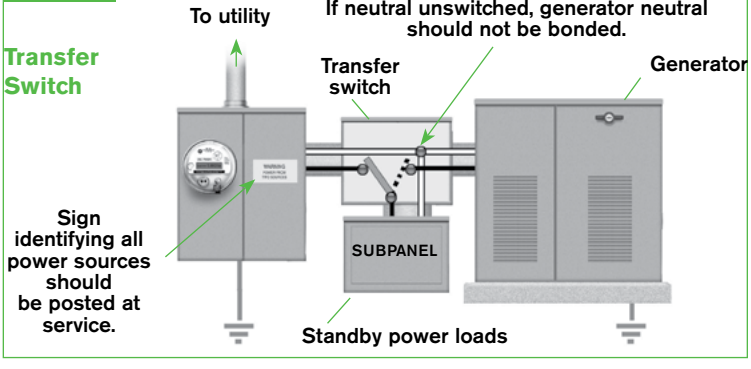
HOT TUB/SPA

Outdoor hot tubs and spas follow the same rules as swimming pools in addition to the general rules below. A hydromassage tub (**p.39**) is not a spa because it is emptied after each use.

General	09 IRC	11 NEC
☐ LFMC or LFNMC up to 6 ft. OK for package unit	[T4202.1]	{680.42A1}
☐ Cord up to 15 ft. OK for GFCI-protected package unit	[4202.2]	{680.42A2}
☐ Bands to secure hot tub staves exempt from bonding	[4204.4]	{680.42B}

Indoor Spas	09 IRC	11 NEC
☐ Indoor packaged units ≤20A OK for cord & plug	[4202.2]	{680.43X}
☐ Min 1 receptacle 6–10 ft. from inside wall of spa	[4203.1.4]	{680.43A1}
☐ Wall switches min 5 ft. from inside wall of spa	[4203.2]	{680.43C}1

FIG. 69



GENERATORS

Generators provide a source of emergency power during a utility outage. Care must be taken to ensure that the 2 sources of power–utility and generator–cannot be connected simultaneously. This dangerous condition results from failure to install proper transfer switches and improper use of portable generators.

Generators	11 NEC
☐ Must be suitable for environment, rainproof if outdoors	{445.10}
☐ Rainproof generators not OK enclosed indoors	{110.3B}
☐ Conductors sized 115% of nameplate current rating	{445.13}
☐ Live or moving parts guarded against accidental contact	{445.14}
☐ GEC req'd for permanently installed generators	{250.30A3}
☐ Remove bonding jumper if transfer switch does not switch neutral F69	{250.24A5}

Transfer Switches F69	11 NEC
☐ Sign req'd at service indicating generator location	{702.8A}
☐ Transfer equipment must prevent simultaneous connection of generator & utility service	{702.6}

ELECTRIC VEHICLE CHARGING

Electric Vehicle (EV) Charging Systems	11 NEC
☐ Systems >20A 125V no exposed live parts	[625.13]
☐ Coupler L&L for EV	{625.16}
☐ Interlock must de-energize connector when uncoupled from EV	{625.18}
☐ Electric vehicle OK as standby power source through listed utility interactive connection	{625.26}

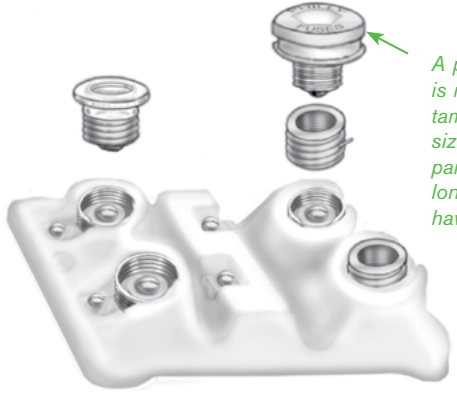
OLD WIRING

A high percentage of residential electrical fires occur in older homes. Proper overcurrent protection helps prevent insulation failure, though in some cases time and exposure take too great a toll on wiring, and it must be replaced with new materials. Fuses provide overcurrent protection only if they are the right size. Too often, they are altered or bypassed (a penny behind the fuse). Older ceramic fuse panels and panels with cartridge fuses also pose a risk of electrocution because of exposed electrical contacts. For these reasons, many insurance companies req upgrading of fuse systems. The references below are from the NEC. The IRC is a code for new construction and does not address old wiring.

Fuses	**11 NEC**
☐ No exposed contact fuseholders (must be dead front) **F70**	{240.50D}
☐ Edison base (plug fuses) not OK for 240V circuits	{240.51A}
☐ Type S fuse req'd if tampering or overfusing exists **F70**	{240.51B}
☐ Type S fuse adapter must be proper size for wire	{240.4D}
☐ No fuses in neutral conductor **F70**	{240.22}

FIG. 70

Ceramic Fuse Holder



A properly sized type S adapter is req'd when a fuse has been tampered with or improperly sized. Open ceramic fuse panels such as these are no longer allowed because they have exposed contacts.

KNOB & TUBE (K&T)

K&T wiring is the oldest wiring method found in American homes. When left in its original state, it can be reliable; safety was inherent in its design. As a wiring method in uninsulated joist and stud cavities it is protected from damage and provided with air circulation, which prevents heat buildup. Unfortunately, when these systems are modified by unqualified persons, the inherent safety of K&T is often compromised. Adding new loads to an old system is tricky and seldom done correctly. Rubber insulation on K&T wiring becomes brittle over time and is prone to mechanical damage, especially when thermal insulation is added to an attic. Older rubber insulation has only a 60°C rating.

General	11 NEC
☐ No new K&T	{394.10}
☐ Additions to existing K&T OK if properly protected	{394.10}
☐ Must enter plastic boxes through separate holes	{314.17C}
☐ Must be protected with loom where entering box	{314.17B&C}
☐ Loom must extend from last insulator to 1/4 in. inside box **F73**	{314.17B&C}
☐ Do not envelop with thermal insulation	{394.12}
☐ Wires must be kept out of direct contact with wood framing	{394.17}
☐ Tubes req'd where passing through framing members **F71**	{394.17}
☐ 3 in. min between wires, 1 in. to surfaces **F72**	{394.19A1}
☐ Conductors on sides (not face) of exposed joists & rafters EXC	{394.23A&B}
• OK on edges or faces of rafters or joists in attics < 3 ft. high	{394.23BX}
☐ Protect with running boards up to 7 ft. high in attic with stairs	{394.23A}
☐ Provide protection where exposed < 7 ft. above floor	{398.15C}

FIG. 71

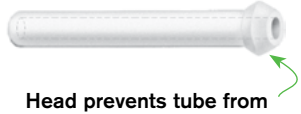


FIG. 72

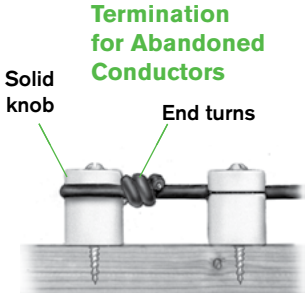
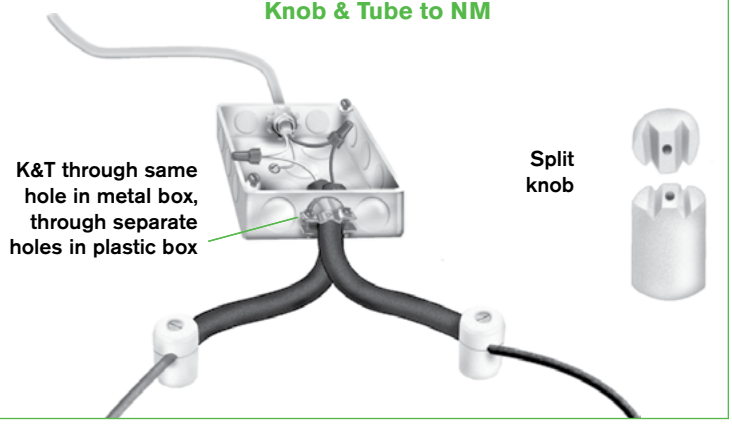


FIG. 73



OLD NM

Pre-1984 nonmetallic sheathed cable contained conductors with insulation rated 60°C. When installed in a hot attic, the ampacity of this old wire is easily exceeded. Precautions must also be taken to isolate this old low-temperature wiring from luminaires that req high-temperature rated connections **F36**. Much of this old wire was used in houses with problematic electrical equipment. Replacement circuit breakers for older panels can be very expensive–providing one more incentive to replace such systems. For further information on old wiring, refer to the Code Check website, *www.codecheck.com*.

Aluminum Wiring — 11 NEC

- ☐ Snap switches with direct Al connection req L&L as "CO/ALR" {404.14C}
- ☐ Receptacles ≤ 20A with direct Al connection req L&L as "CO/ALR" {406.2C}
- ☐ Al to Cu splicing devices must be listed for same {110.14}
- ☐ Terminals (including breaker terminals) for Al req L&L {110.14A}

Pre-1984 NM — 11 NEC

- ☐ Derate for ambient temp {310.10, T310.16}
- ☐ No 60°C conductors in attics > 131°F {T310.16}
- ☐ No direct connection to luminaires that req > 60°C conductors {410.117A}
- ☐ Isolate old wiring from high-temp wiring **F36** {410.117A}
- ☐ Box for tap conductors min 1 ft. from luminaire, max 6 ft. wire {410.117C}

REPLACEMENT RECEPTACLES

Houses built before adoption of the 1962 NEC will not have 3-hole receptacles in all locations. Appliances with 3-prong cords are designed to be used with only grounded 3-hole receptacles. A GFCI can provide shock hazard protection for 2-conductor circuits; though without an EGC, it may not protect equipment.

General — 11 NEC

- ☐ AFCI protection req'd for replacements in areas where circuit req's AFCI protection (**p.24**) effective 1/1/2014 {406.4D4}[50]
- ☐ Protection can be breaker, AFCI outlet device, or upstream AFCI outlet {406.4D4}[50]
- ☐ Replacement receptacles must be tamper-resistant {406.4D5}[50]
- ☐ Outdoor wet location replacement receptacles must be WR {406.4D6}[50]

Replacements When No Grounding Present — 11 NEC

- ☐ 2-hole receptacle OK if in area where GFCI not req'd {406.4D2a}
- ☐ Must have GFCI protection in area that now req's GFCI {406.4D3}
- ☐ OK to install GFCI even if no ground present {406.4D2b&c}
- ☐ Non-grounded GFCI or GFCI-protected receptacles req label stating "No Equipment Ground" {406.4D2b}
- ☐ Ungrounded 3-hole receptacle supplied through a GFCI also req label stating "GFCI Protected" {406.4D2d}
- ☐ Separate EGC can be added from receptacle box & connect to service enclosure, GEC, or ground bar of panel at circuit origin {250.130C}
- ☐ OK to run EGC separately from circuit conductors {300.3B2}
- ☐ Not OK to jumper neutral & EGC {250.142B}

Replacements When Grounding Present in Box — 11 NEC

- ☐ Replacements must be 3-hole if EGC present {406.4D1}
- ☐ Bond 3-hole receptacle to grounded box with wire OR {250.146}
  - Use grounding-type receptacle (captive metal screw from yoke) {250.146B}

TABLE 23 SIGNIFICANT CHANGES IN THE 2011 NEC & THE 2009 IRC / 2008 NEC

#	Page	Code & Year	Description
1	7	11 NEC	Exemption for guarded/isolated roof areas
2	10	11 NEC	Seal underground conduits entering buildings
3	10	11 NEC	Max 1 branch circuit back to source building
4	11	11 NEC	Clarified when cord-set GFCIs req'd
5	16	08 NEC & 09 IRC	Allows isolated foundation pier rebar as Ufer
6	19	08 NEC & 09 IRC	List of specific acceptable grounding connection methods replaced simple prohibition against sheet metal screws
7	19	11 NEC	Bonding req'd at line-side reducing washers
8	20	08 NEC & 09 IRC	Intersystem bonding method specified
9	21	08 NEC & 09 IRC	OCPDs not allowed over steps of a stairway
10	21	08 NEC & 09 IRC	Labeling independent of transient conditions
11	21	08 NEC & 09 IRC	Labeling of spare breakers
12	21	08 NEC & 09 IRC	Neutral current not allowed through enclosure
13	21	08 NEC & 09 IRC	All multiwire circuits handle tie or single-handle 2-pole
14	21	08 NEC & 09 IRC	Multiwire circuits req'd to be grouped in panel
15	21	11 NEC	Warning label to identify source of feed-through circuits in panel

#	Page	Code & year	Description
16	24	08 NEC & 09 IRC	Expanded AFCI other rooms than bedrooms
17	24	11 NEC	AFCI req'd for replacement or extension circuits
18	25	09 IRC	Conformed to NEC luminaire box ratings
19	29	11 NEC	GFCI controls req'd to be readily accessible
20	29	08 NEC & 09 IRC	GFCI exceptions eliminated for garages & unfinished basements
21	29	08 NEC & 09 IRC	GFCI within 6 ft. of laundry, utility, or bar sinks
22	29	11 NEC	GFCI within 6 ft. all sinks in addition to those req'd for kitchen countertops
23	29	08 NEC & 09 IRC	GFCI protection req'd for 240V boat hoists
24	30	08 NEC & 09 IRC	Receptacles req'd by NEC 210.52 or IRC 3901.1 also req'd to be TR
25	30	11 NEC	Exceptions for tamper-resistant receptacles
26	31	08 NEC & 09 IRC	Clarification that switched receptacles do not count as part of req'd receptacles
27	31	11 NEC	New requirement for receptacles in foyers
28	32	11 NEC	Countermounted bath receptacles allowed
29	32	08 NEC & 09 IRC	Receptacles req'd for balconies > 20 sq. ft.
30	32	11 NEC	Removed exemption for balconies < 20 sq. ft.
31	32	08 NEC & 09 IRC	Weather-resistant receptacles req'd

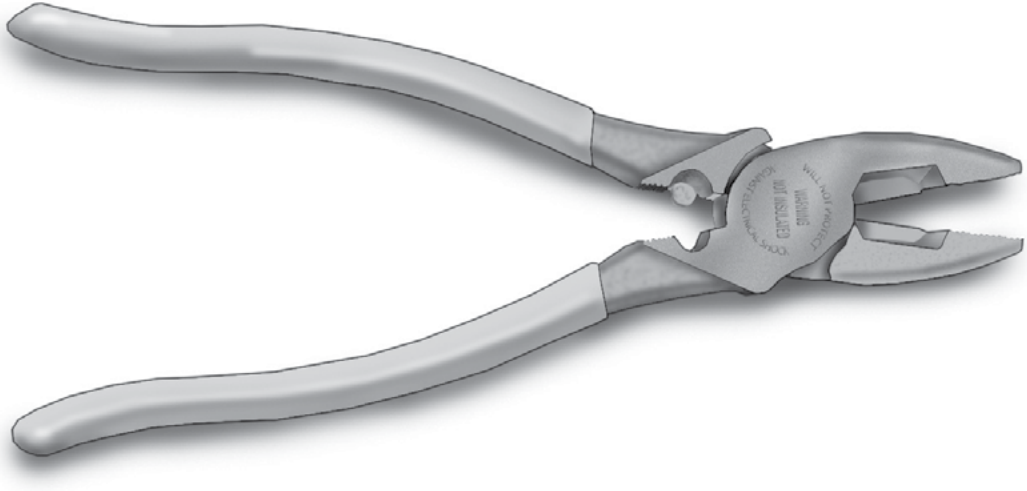
TABLE 23 SIGNIFICANT CHANGES IN THE 2011 NEC & THE 2009 IRC / 2008 NEC (CONT.)

#	Page	Code & year	Description
32	33	08 NEC & 09 IRC	Clarified when range or sink divides island or peninsula countertop into separate spaces
33	36	11 NEC	Neutral req'd in switch box
34	36	11 NEC	Exceptions if neutral can be added at later time
35	37	08 NEC & 09 IRC	L&L LEDs allowed in closet storage areas
36	39	08 NEC & 09 IRC	Hydromassage tub req's individual circuit
37	39	08 NEC & 09 IRC	Hydromassage area piping bonded to motor
38	41	09 IRC	NFPA 72 systems must become permanent part of property to replace req'd alarms
39	41	09 IRC	CO alarms req'd–hardwired like smoke alarms
40	42 45	08 NEC & 09 IRC	Derate > 2 NM cables in contact with thermal insulation
41	44	11 NEC	No cables or raceways other than RMC or IMC allowed < 1½ in. from sheet steel roof deck
42	46	08 NEC & 09 IRC	SE cable no longer exempt from 60° limitation that applies to NM
43	48	08 NEC & 09 IRC	Wiring in raceways above grade in wet locations req'd to be wet-rated
44	49	08 NEC & 09 IRC	FMC no longer allowed in wet locations
45	54	11 NEC	PV installations req qualified personnel
46	54	11 NEC	DC AFCI protection req'd
47	56	11 NEC	Screens & metal windows < 5 ft. from pool edge included in equipotential bonding
48	56	08 NEC & 09 IRC	Specific methods for creating equipotential bonding grid for nonconductive pool shells & for extending past pool edge
49	56	08 NEC & 09 IRC	Contact with pool water to equipotential bond
50	60	11 NEC	Replacement receptacles req type & protection of new receptacles for the area in which they are installed

TABLE 24 COMMON NUMBERING SYSTEM FOR WIRE, CABLE & RACEWAY ARTICLES (BASED ON NEC CHAPTER 3)

I. GENERAL	II. INSTALLATION			III. CONSTRUCTION SPECIFICATIONS
xxx.1 Scope	xxx.10 Uses Permitted	xxx.26 Bends: Number in 1 Run	xxx.44 Expansion Fittings	xxx.100 Construction
xxx.2 Definitions	xxx.12 Uses Not Permitted	xxx.28 Reaming & Threading	xxx.46 Bushings	xxx.104 Conductors
xxx.6 Listing Requirements	xxx.14 Dissimilar Metals	xxx.28 Trimming	xxx.48 Joints	xxx.108 Equipment grounding
	xxx.16 Temperature Limits	xxx.30 Securing & Supporting	xxx.50 Conductor Terminations	xxx.120 Marking
	xxx.20 Size	xxx.40 Boxes & Fittings	xxx.56 Splices & Taps	
	xxx.22 Number of Conductors	xxx.42 Couplings & Connectors	xxx.60 Grounding	
	xxx.24 Bending radius		xxx.80 Ampacity	

In 1752, Benjamin Franklin, aided by his son, William, conducted the famous, but highly dangerous kite experiment. For an animated explanation, visit: www.codecheck.com/cc/BenAndTheKite.html.



Side Cutters