

Residential Code Series – Electrical and Photovoltaic

Fall 2019 Career Development Series

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DAS Office of Education and Data Management

**Residential Code Series:
Electrical**

**PART ONE
Plan Review**



Plan Review Objectives Electrical

At the conclusion of this plan review section, participants should be able to:

1. Determine construction documents needed (cut sheets...)
2. Evaluate service size, feeder size, location...
3. Verify that equipment chosen meets requirements
4. Evaluate compliance for proposed installation of amenities based on drawings
5. Evaluate PV system for installation
6. Evaluate distribution system based on drawings
7. Develop a time table for inspections and testing

IRC Plan Review Electrical

Part1

What you **should** be getting for Construction Documents

R106.1

- Two or more sets
- Design Professional where required
- Can request more information
 - *Exception* : BO authorized to waive certain documents and data

IRC Plan Review Electrical

R106.1.1 Information on construction documents

- Suitable material
- Electronic media (where approved by BO)
- Sufficient clarity
- Nature and extent of the work
- Conforms to provisions of code

Manufacturer's installation instructions

- Available on job site at time of Inspection (R106.1.2)



IRC Plan Review Electrical

What was submitted for this project ? _____

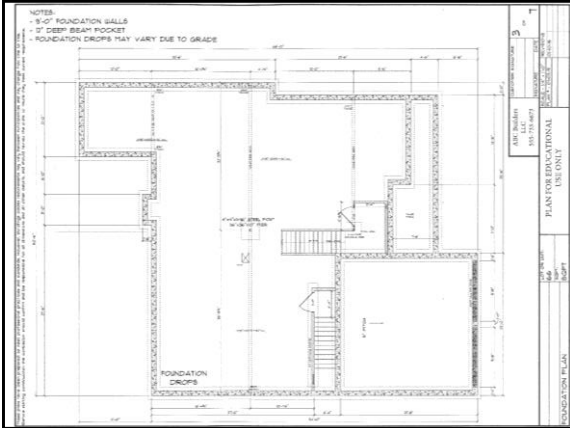
- 7 pages of drawings
- REScheck compliance certificate with checklist

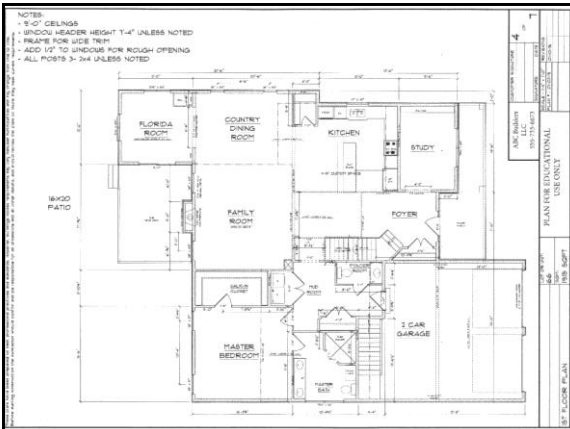
What other information (electrical) should we request for this project?

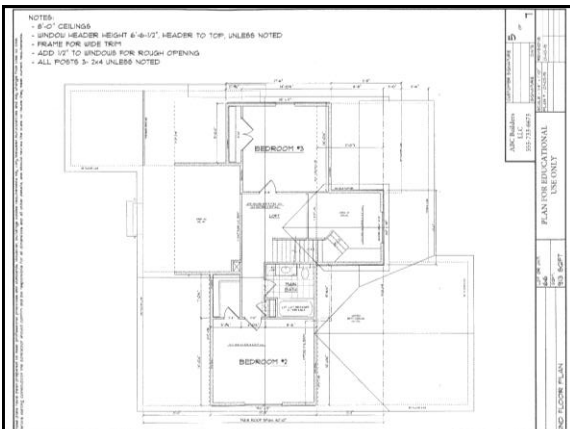




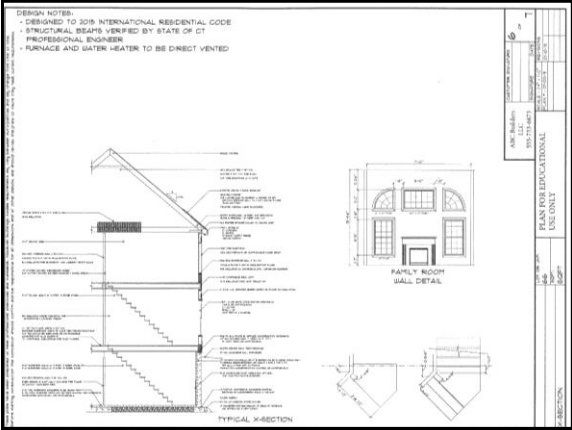


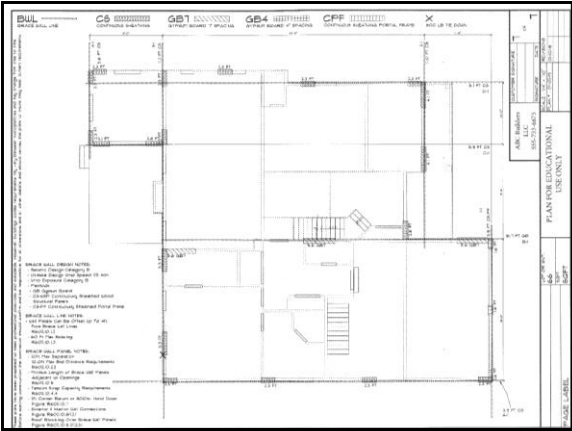










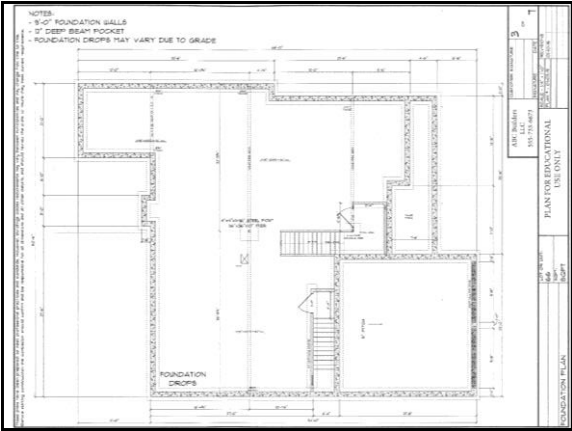




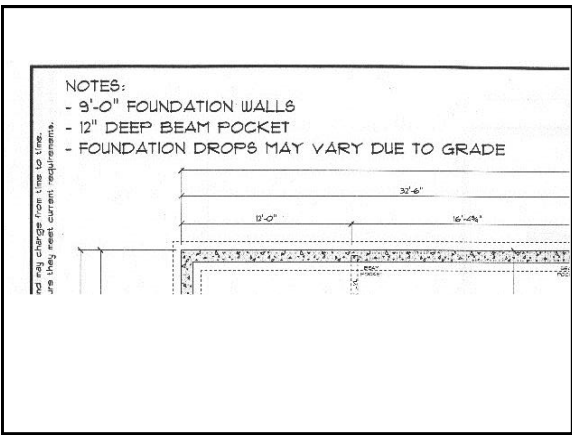


Electrical Plan Review

Horizontal lines for notes

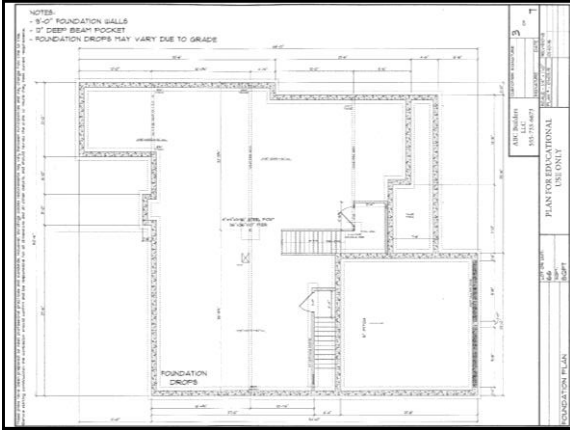


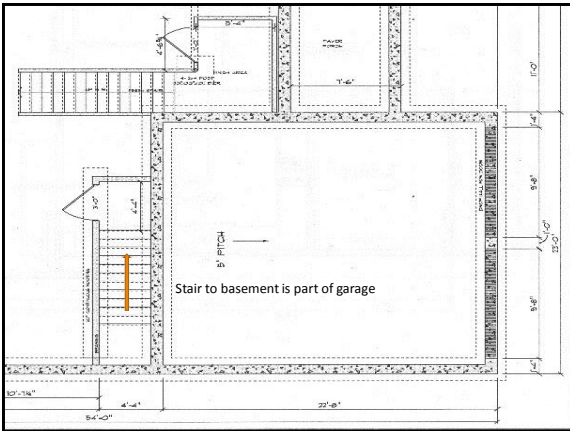
Horizontal lines for notes



Horizontal lines for notes

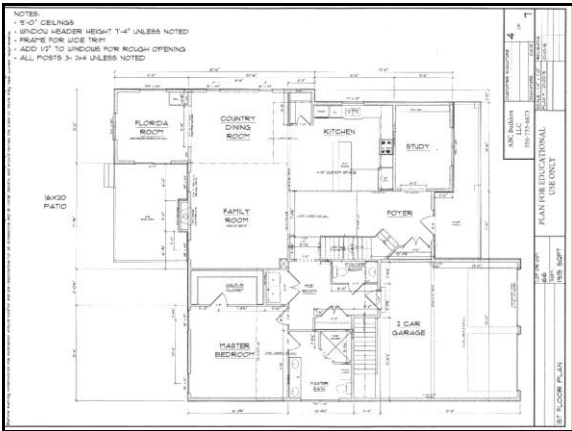


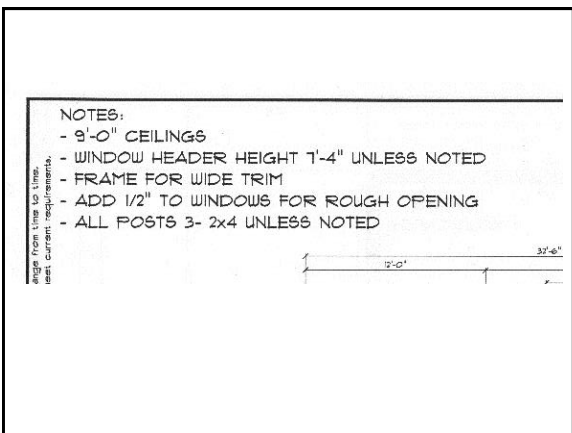




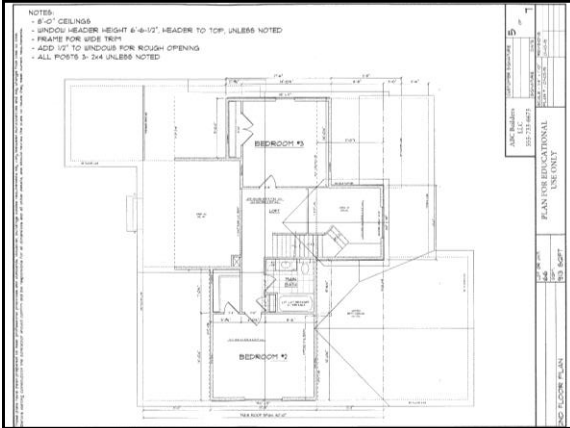


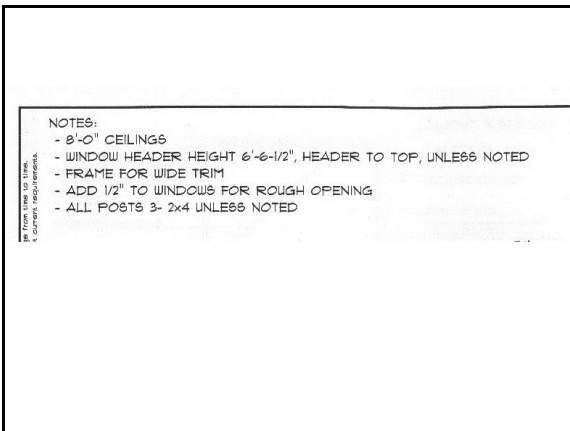


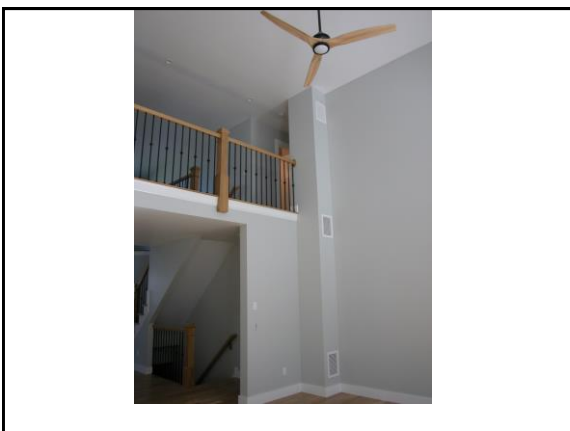


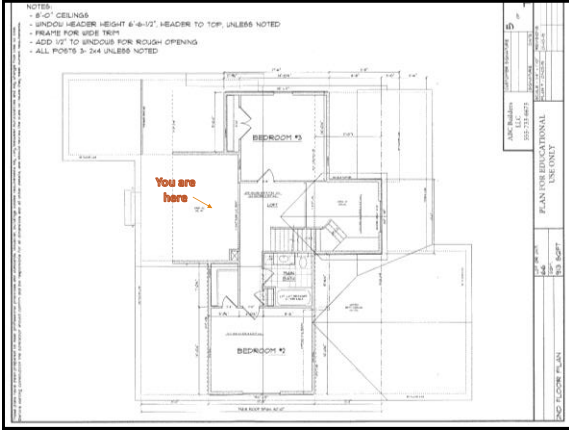


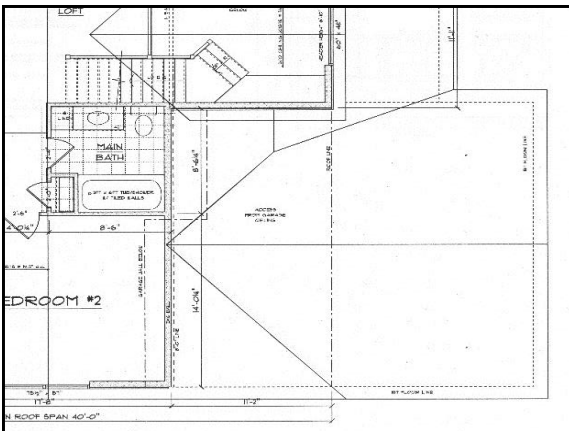


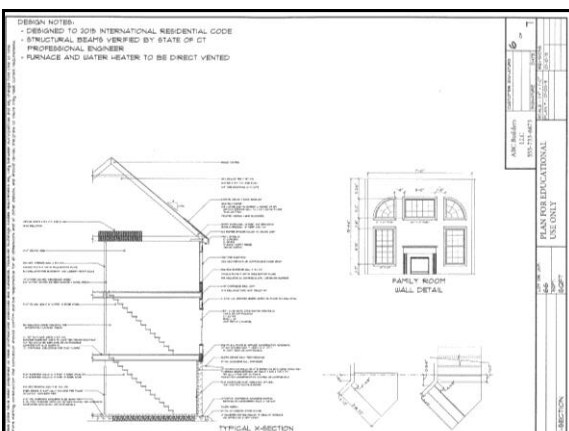




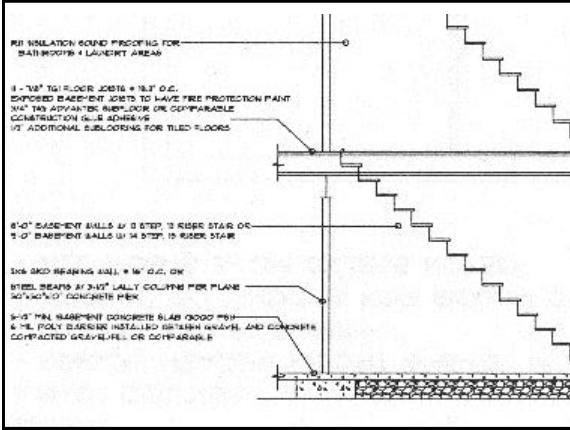


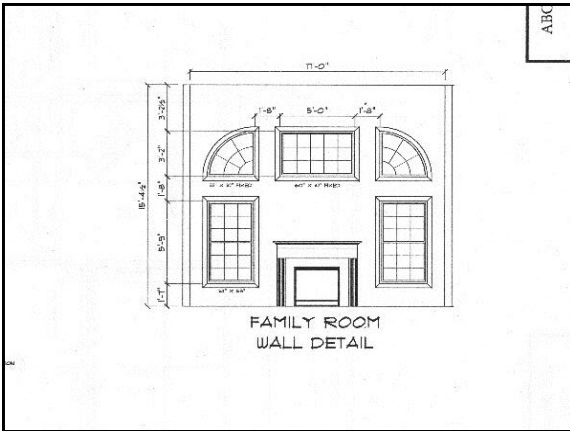


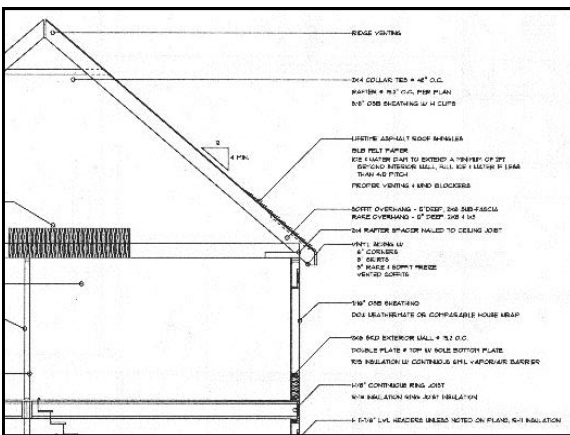




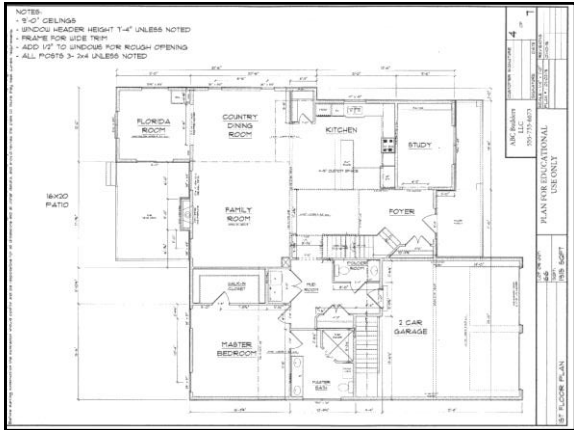












Electrical Plan Review

Service Size?
 Location?
 Number of circuits?

Receptacles required
 (minimum)

Lighting and controls

Special items:
 Hardwired
 Disconnects

210.11 Branch Circuits Required

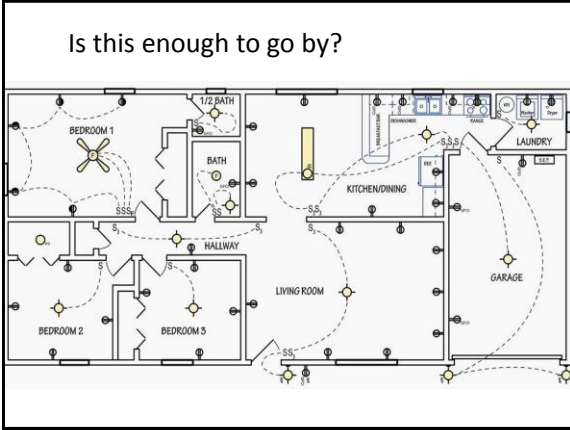
(C) Dwelling Units. - (1) Small-Appliance Branch Circuits. 2 20 amp small-appliance branch circuits. (normally split by sink, R and L)

(2) Laundry Branch Circuit. 1 20 amp laundry circuit and no other outlets.

(3) Bathroom Branch Circuit. 1 20 amp circuit to supply bathroom receptacle outlets and no other outlets. *Can serve other bathrooms, but nothing else.*

(new 2017) (4) Garage Branch Circuit. 1 20 amp circuit (GFCI) to serve garage receptacles. *Can also serve outside receptacles.*





Based on 2017 NEC

8th EDITION Save Time • Save Money • Take Anywhere
Updated to the Current National Electrical Code

Code Check Electrical

An Illustrated Guide to Wiring a Safe House

Douglas Hansen, Skip Walker, Redwood Kardon • Illustrated by Paddy Murphy

Services
Grounding
Panels
AFCIs & GFCIs
Branch Circuits
Boxes
Lighting
Appliances
Cables
Conduits
Photovoltaics
Code Changes

ICC INTERNATIONAL CODE CONGRESS

KITCHENS

At least two 20A small-appliance branch circuits are required in kitchens and dining areas. These circuits are in addition to those for lighting or permanently installed appliances. Additional circuits can be installed for specific appliances, such as refrigerators. Receptacles are required for countertop spaces 1 ft. or more in width. See 210.52 for rules on AFCIs & GFCIs for rules on GFCIs.

Branch Circuits

- At least 2 20A small-appliance branch circuits required. 210.11(C)
- Small-appliance circuits must serve all countertop & exposed wall receptacles in kitchen, dining room, pantry & similar areas. EXC 210.82(B)
- Switched receptacles dining room light 210.52(B)(4)
- 15A or 20A individual branch circuits for specific appliances 210.52(B)(4)
- No other outlets looking light on small-appliance circuits EXC: 210.52(B)
- Receptacles for clock or gas range grates OK 210.52(C)
- Dishwasher & disposer req separate circuits if combined rating exceeds branch circuit rating 210.19(A)
- 40A 240V circuits OK for range receptacle outlets 210.31(B)
- 60A or 80A 240V circuits OK for built-in cooking appliances 210.32(C)

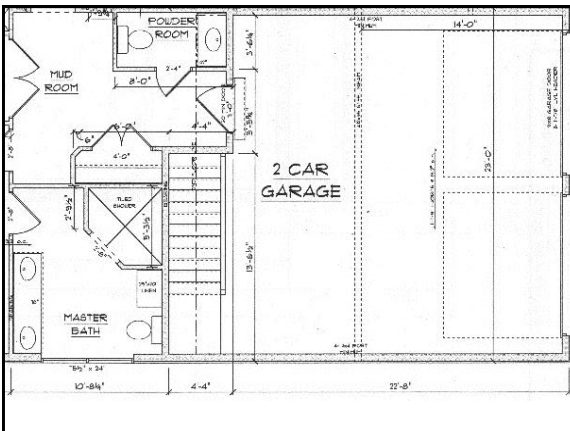
Receptacles for Countertops & Work Surfaces

- Receptacles req'd for all wall counter spaces 2 1/2 in. wide 210.52(C)
- No point along wall line > 24 in. horizontally from receptacle P25 210.52(C)
- Countertop spaces separated by ranges, refrigerators, or sinks considered separate countertop spaces P25 210.52(C)
- Area behind sink or range considered countertop space if 2 1/2 in. to wall or 2 1/8 in. to corner P29 210.52(C)
- Multi-outlet assembly in bottom of upper cabinet OK as req'd receptacle if 2 1/2 in. above countertop 210.52(C)
- Peninsulas req receptacle if long dimension 2 1/2 ft. & short dimension 12 in. 210.52(C)
- Peninsulas measured from corner perpendicular wall P25 210.52(C)
- Each island countertop space req 2 1/2 in. long dimension & 12 in. short dimension req'd receptacle P22(B) 210.52(C)
- Sink or range with < 12 in. behind divides island or peninsula where overhanging counter 4 6 in. past support base P27 210.52(C)
- No floor-up countertop receptacles 210.52(C)
- Listed pop-up receptacle assemblies OK P27 210.52(C) & 409.5E
- Counter receptacles do not count as wall space receptacles P29 210.52(A)

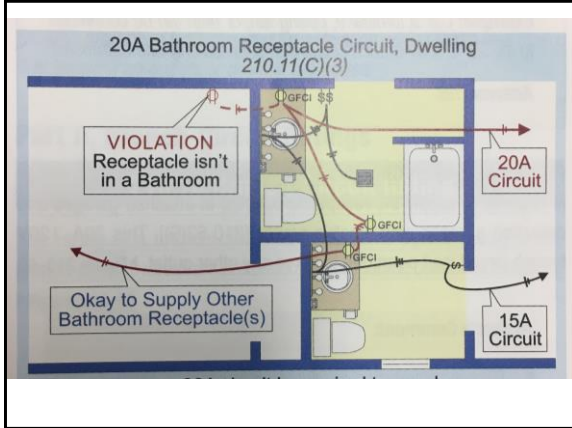


Location of:	Arc Fault 210.12	Ground Fault 210.8
All 120v, single phase, 15- and 20 ampere branch circuits supplying outlets or devices installed in dwelling unit :	All 125v, single phase, 15 and 20 ampere receptacles installed in dwelling unit:	
Kitchens	(1-10)	
Family rooms	Bathroom	
Dining rooms	Garages/ accessory buildings	
Living rooms	Outdoors	
Parlors	Crawl spaces	
Libraries	Unfinished basement	
Dens	Kitchens- serve countertops	
Bedrooms	Sink within 6'	
Sunrooms	Boathouses	
Recreation rooms	Bathtub/shower stall within 6'	
Closets	Laundry areas	
Hallways		
Laundry areas		
Similar locations		

List of Amenities	
Kitchen:	Foyer:
Range	Hanging Light
Range Hood	
Dishwasher	Front Porch:
Disposal	GFCI receptacle
Microwave	Study:
Refrigerator	
Island Counter	







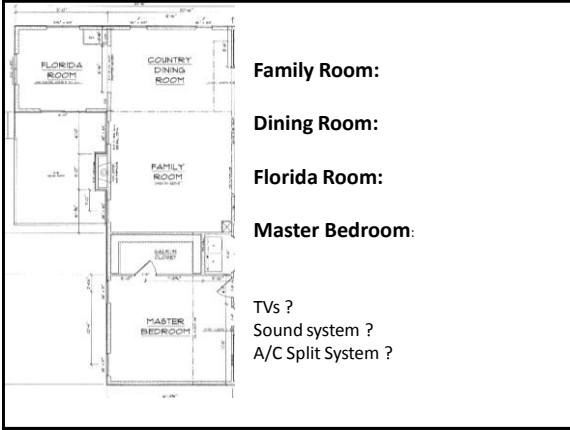
Bathroom

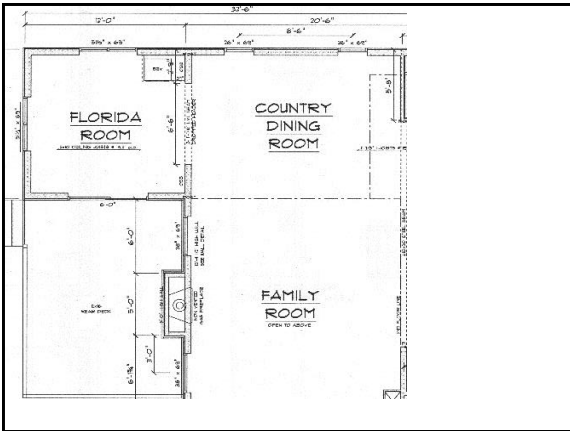
- 210.52 D**
At least 1 15a or 20a 125v receptacle within 3' of EACH basin not below top of basin more than 12"
- 210.8 A 1**
GFCI – all receptacles
- 406.12**
Tamper-Resistant Receptacle
- 210.11 C 3**
At least 1 20a 120v branch circuit for receptacle. Not permitted to serve lighting in bath, but can supply other bathroom receptacles.
- 210.70 A 1**
At least one wall switch. Occupancy sensors allowed (vacancy sensor better?)
- 404.2 C**
Grounded (neutral) conductor to be in switch box

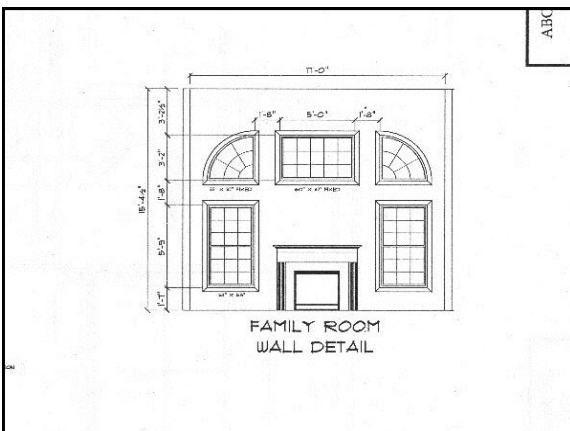
List of Amenities

- | | |
|-----------------|---------------------------------|
| Kitchen: | Foyer: |
| Range | Hanging Light |
| Range Hood | |
| Dishwasher | Powder Room: |
| Disposal | Master Bath and Laundry: |
| Microwave | Mud room: |
| Refrigerator | |
| Island Counter | Garage: |
| | 2 car openers |
| | Electric charger? |
| Study: | |



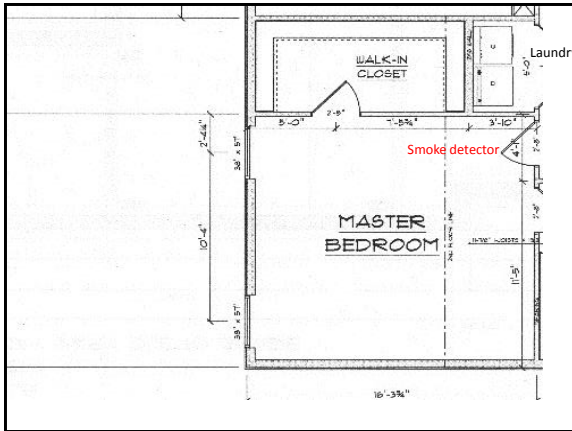






A sneak peek at the Framing





Smoke Detectors/CO Detectors 2015 IRC 314, 315

Smokes UL 217

Each story, including basement and habitable attic (story?)

Each sleeping room and adjoining area (hall) 314.3

3' from bath door

3' from vent or paddle fan zone

House power (14/3 wire, black and white) and battery back up 314.6

Interconnected (via 14/3 wire, red as signal) (NEST system OK) 314.4

AFCI

CO

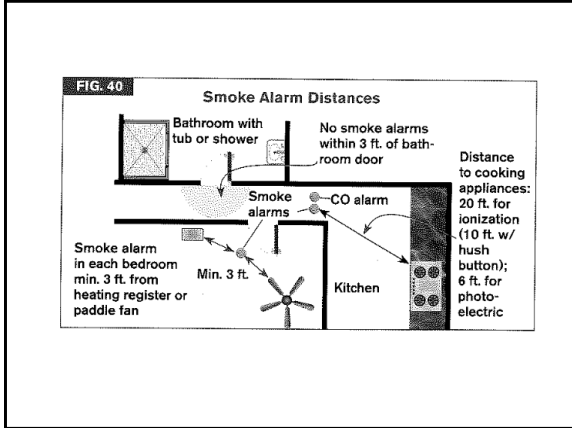
Outside sleeping area in immediate vicinity of bedroom 315.3

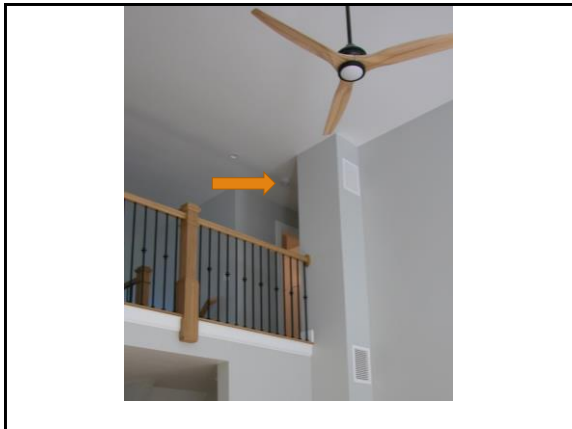
In bedroom w fuel fired appliance (log) 315.3

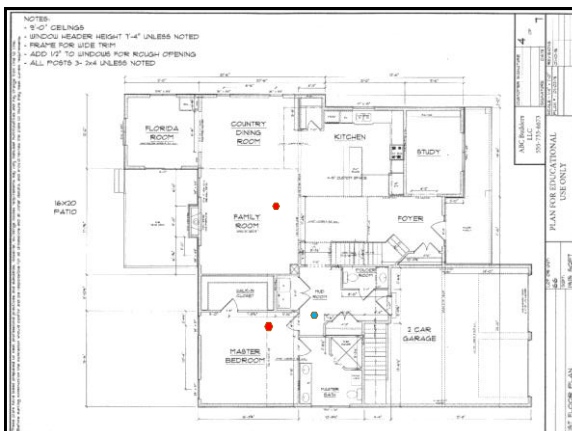
House power and battery backup 315.5

Dwelling with fuel fired system and/or attached garage 315.2.1

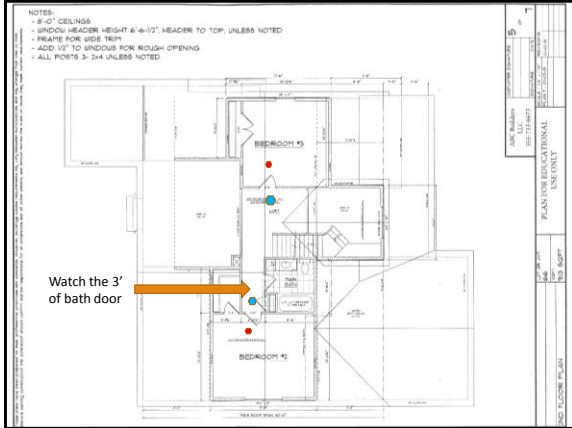










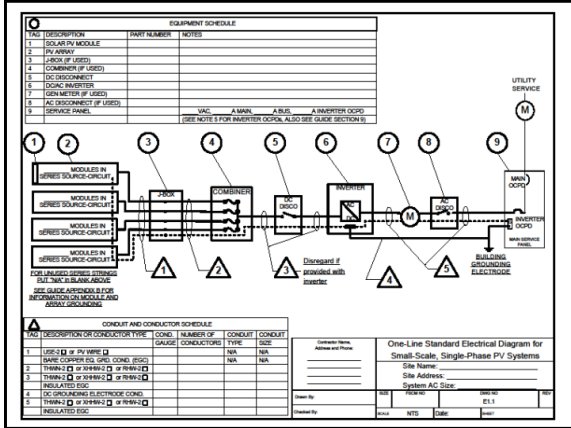



- ### Working list of Amenities
- Gas cooktop
 - Electric wall oven
 - Gas water heater
 - Gas fireplace
 - Gas furnace
 - Duct system
 - HVAC 2 ton unit
 - Furnace Blower Motor
 - Outside Condensing unit
 - Radon fan
 - Exhaust fans-bath (2)
 - Electric Dryer
 - Dishwasher
 - Added a PV system
 - Tesla Powerwall
 - Gateway Backup

Required Information for PV Permit

- Site plan showing location of major components on the property. This drawing need not be exactly to scale, but it should represent relative location of components at site. PV arrays on dwellings need a 3' access path from eave to ridge. (AMIND 2015 IRC 324.7)
 Exception: Installed on one side and there is clear access from opposite side. (then you can fill one side from rake to rake, eave to ridge.)
- Electrical diagram showing PV array configuration, wiring system, overcurrent protection, inverter, disconnects, required signs, and ac connection to building.
- Specification sheets and installation manuals for all manufactured components including, but not limited to, PV modules, inverter(s), combiner box, disconnects, and mounting brackets.








**Manufacturers
Installation
Instructions**

Contains valuable information

Should be provided

Should be on site upon inspection



Powerwall 2 AC Installation Manual
with Backup Gateway

Powerwall Mechanical Specifications

Height	1150 mm (45.3 in)
Width	750 mm (29.7 in)
Depth	155 mm (6.1 in)
Weight	125 kg (276 lbs)

Backup Gateway Electrical Specifications 276 lbs !!!

Disconnect Current	200 A
Maximum Input Short Circuit Current	10 kA
Overcurrent Protection Breaker ^a	100-200 A, Service-Entrance Rated
Overvoltage Category	Category IV
AC Meter	Revenue grade (+/- 1%)

^a Circuit breaker required for installation at service entrance

Backup Gateway Environmental Specifications

Operating Temperature	-20°C to 50°C (-4°F to 122°F)
Operating Humidity (RH)	Up to 100%, non-condensing
Maximum Elevation	3000 m (9843 ft)
Enclosure Type	NEMA 3R
Ingress Rating	IP44
Pollution Degree Rating	PD3

Backup Gateway Mechanical Specifications

Height	740 mm (29.1 in)
Width	378 mm (14.9 in)
Depth	129 mm (5.1 in)
Weight	16.4 kg (36 lbs)



BREAK

**Load Calculation 220.82
Dwelling Unit**

Optional method for feeder and service load calculations

You can use the optional method [Art. 220, Part IV] only for dwelling units served by a single 120/240V or 120/208V 3-wire set of service or feeder conductors with an ampacity of 100A or larger [220.82]. The optional method consists of three calculation steps:

- 1.General loads [220.82(B)]
- 2.Heating and air-conditioning load [220.82(C)]
- 3.Feeder/service conductors [310.15(B)(6)]

Step 1: General loads [220.82(B)]

The general calculated load must be at least 100% for the first 10kVA, plus 40% of the remainder of the following loads:

- 1. General lighting and receptacles: 3VA per sq ft
- 2. Small-appliance and laundry branch circuits: 1,500VA for each 20A, 120V small-appliance and laundry branch circuit specified in 220.52.
- 3. Appliances: The nameplate VA rating of all appliances and motors that are fastened in place (permanently connected) or located on a specific circuit, other than heating or air-conditioning. (Heating and AC is in step 2)

Be sure to calculate the range and dryer at their nameplate ratings.



Step 2: Heating and air-conditioning load [220.82(C)]

Use the largest value from (1) through (6):

1. Air-conditioning equipment: 100%
2. Heat-pump compressor without supplemental heating: 100%
3. Heat-pump compressor and supplemental heating: 100% of the nameplate rating of the heat-pump compressor and 65% of the supplemental electric heating for central electric space-heating systems. If the control circuit is designed so that the heat-pump compressor can't run at the same time as the supplementary heat, omit the compressor from the calculation.
4. Space-heating units (three or fewer separately controlled units): 65%.
5. Space-heating units (four or more separately controlled units): 40%.
6. Thermal storage heating: 100%.

Step 3: Feeder/service conductors [310.15(B)(7)]

•400A and less.

For individual dwelling units of one-family, two-family, and multi-family dwellings, use 310.15(B)(7) to size 3-wire, single-phase, 120/240V or 120/208v service conductors (including neutral conductors) that serve the entire load. Feeder conductors aren't required to have an ampacity rating greater than the service conductors. These conductors shall be permitted to have an ampacity not less than 83% of the service rating.

200A Service x 83% = 166A rated conductors (minimum)

Table 310.15 (B)(16) Aluminum THWN 75 degree column(due to terminals)

180Amp = 4/0 Aluminum conductors (or 175Amp 2/0 copper)

EXAMPLE:

What size service is required for a 1,500-sq-ft dwelling unit containing the following loads?

- Cooktop: 6,000VA
- Disposal: 900VA
- Dishwasher: 1,200VA
- Dryer: 4,000VA
- Ovens (two): 3,000VA each
- Water heater: 4,500VA
- A/C: 17A, 240V
- Electric heating (one control unit): 10kVA



Step 1: General loads [220.82(B)]

General lighting: 1,500 sq ft x 3VA = 4,500VA
 Small-appliance circuits: 1,500VA x 2 circuits = 3,000VA
 Laundry circuit: 1,500VA
 Bathroom circuit: ? Required branch circuits 210.11 C, but not calculated.
 Garage circuit: ?Yet

Appliances (nameplate):
Cooktop: 6,000VA **Disposal:** 900VA
Dishwasher: 1,200VA **Dryer:** 4,000VA
Ovens (two) (each 3 kW or 3000VA): 6,000VA
Water heater: 4,500VA (or 4500w)

Total connected load: 31,600VA (Now apply demand factors !)

First 10kW at 100%: 10,000VA x 1.00 = 10,000VA

Remainder at 40%: 21,600VA x 0.40 = 8,640VA

Calculated general load: 10,000VA + 8,640VA = **18,640 VA**

Step 2: Air-Conditioning vs Heat [220.82(C)]

Air-conditioning at 100% [220.82(C)(1)] vs. electric space heating at 65% [220.82(C)(4)]

Air conditioner [Table 430.248]:
 A/C VA = V x A
 A/C VA = 240V x 17A
 A/C VA = **4,080 VA**

Electric space heat: 10,000VA x 0.65 = **6,500VA**
Use the largest value for step 3

Step 3: Feeder/service conductors [310.15(B)(6)]

Calculated general load (Step 1): **18,640VA**
 Heat calculated load (Step 2): **6,500VA**

Total calculated load = 18,640VA + 6,500VA = **25,140VA**
 $I = VA \div E$
 $I = 25,140VA \div 240V = **105A**$
This service must be greater than 100 A

Now, let's go back to our house...

Gas cooktop Electric Dryer **5000VA** (or nameplate)
 Wall Oven **6500VA** (220.54)
 Gas water heater
 Gas fireplace PV system
 Gas furnace
 Duct system
 Blower Motor 10.9 x 120v= **1308VA**
 HVAC 2 ton unit
 Outside Condensing unit 14.1A x 240v = **3384VA**
 Radon fan **55w**
 Exhaust fans-bath 2x **36w= 72VA**
 Garbage Disposal **1hp** (430.248) 16a x 120v= **1920VA**
 Dishwasher **1200VA**



Step 1: General loads [220.82(B)]
"outside dimension of each floor"
 General lighting: $(913+1915+1870)\text{sq ft (future basement)} \times 3\text{VA} = 4698 \times 3 = 14,094\text{VA}$
 Small-appliance circuits: $1,500\text{VA} \times 2 \text{ circuits} = 3,000\text{VA}$ (220.52)
 Laundry circuit: $1,500\text{VA}$

Appliances (nameplate):
 Range: gas cooktop Exhaust Fan: 72 VA
 Oven: 6,500 VA Dryer: 5,000 VA (220.54)
 Disposal: 1,920 VA Radon Fan: 55 VA
 Dishwasher: 1,200 VA Water heater: gas
 (when using Optional Method – no continuous/non-continuous calculations)

Total connected load: 33,341VA (Now apply demand factors !)

First 10kW at 100%: $10,000\text{VA} \times 1.00 = 10,000\text{VA}$

Remainder at 40%: $23,341\text{VA} \times 0.40 = 9,336.4\text{VA}$

Calculated general load: $10,000\text{VA} + 9,336.4 = \mathbf{19,336.4\text{VA}}$

REScheck Software Version 4.6.5
Compliance Certificate

Project Unit # = CHDM Heights
 Energy Code: 2015 IECC
 Construction Type: Single Family
 Project Name: New Construction
 Construction Method: Single-Family Detached
 Constructioned Floor Area: 4,743 sq ft
 Climate Zone: 7a
 Permit Number: S 15792 (HDD)

Construction Site: Cheshire, CT 06410
 Designer/Contractor: [Redacted]

Compliance: Passes using UA trade-off
 Compliance: 0.4% Better than code (Minimum UA: 496 U-Value: 0.85)
 The UA Ratio or UA% value is based on the UA Ratio or UA% based on code trade-off code.

Assembly	Area (sq ft)	U-Value	U-Factor	UA
Floor 1: AB-Wood joist/Foam Over Outside Air	27	20.0	0.0	0.024
Ceiling 1: R-19 Insulation/Energy Traces	1,024	25.0	24.0	0.026
Ceiling 2: R-19 Insulation/Energy Traces	80	20.0	2.5	0.024
Wall 1: Vinyl Siding	843	13.0	0.0	0.018
Window 1: Vinyl/Aluminum Frame Double Pane with Low-E Insulation	56		0.270	1.5
Door 1: Solid Core	41		0.170	1.0
Ceiling 2: R-19 Insulation/Energy Traces	843	13.0	0.0	0.018
Window 2: Vinyl/Aluminum Frame Double Pane with Low-E Insulation	114		0.270	3.1
Door 2: Solid Core	72		0.170	1.0
Window 3: Vinyl/Aluminum Frame Double Pane with Low-E Insulation	56		0.270	1.5
Window 4: Vinyl/Aluminum Frame Double Pane with Low-E Insulation	41		0.270	1.0

Report date: 03/10/19
 Page 1 of 10

Step 2: Air-Conditioning versus heat [220.82(C)]

Air-conditioning at 100% [220.82(C)(1)] VS. electric space heating at 65% [220.82(C)(4)]

Air conditioner [nameplate or Table 430.248]:
 $A/C\text{ VA} = V \times A$
 $A/C\text{ condenser VA} = 240\text{V} \times 14.1\text{A} = 3384\text{VA}$
 Furnace blower motor = $120\text{V} \times 10.9\text{A} = 1308\text{VA}$
 $A/C\text{ VA} = \mathbf{4,692\text{VA}}$

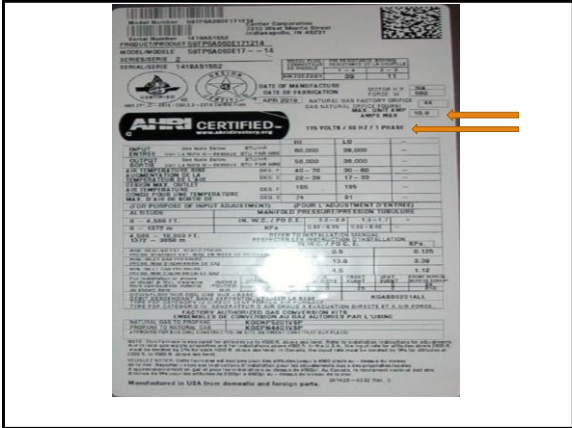
Electric space heat: NA
Use the largest value for step 3

Step 3: Feeder/service conductors [310.15(B)(6)]

Calculated general load (Step 1): $\mathbf{19,336\text{VA}}$
 AC calculated load (Step 2): $\mathbf{4,692\text{VA}}$

Total calculated load = $19,336\text{VA} + 4,692\text{VA} = \mathbf{24,028\text{VA}}$
 $I = \text{VA} \div E$
 $I = 24,028\text{VA} \div 240\text{V} = \mathbf{100.11\text{A}}$
 This service to be over 100A. But what about GDO, Refrig, freezer, charger, sump pump...





Are you comfortable with the scope of the project?

Do you have enough information?

What's the time table for the job?

Here's the inspection schedule

Issue the permit

Bob the Builder

New Construction Inspections

2015 IRC R109 Inspections:

- Foundation
- Plumbing, mechanical, gas, and electrical systems
- Floodplain
- Frame and masonry
- Insulation
- Other
- Fire resistant construction
- additional electrical
- Final
- 109.1.7 Posting of required inspections
- New construction
- Single family dwelling
- 200a 120/240v underground utility service
- Natural Gas
- City Water
- City Sewer



Residential Inspection checklist (electrical)

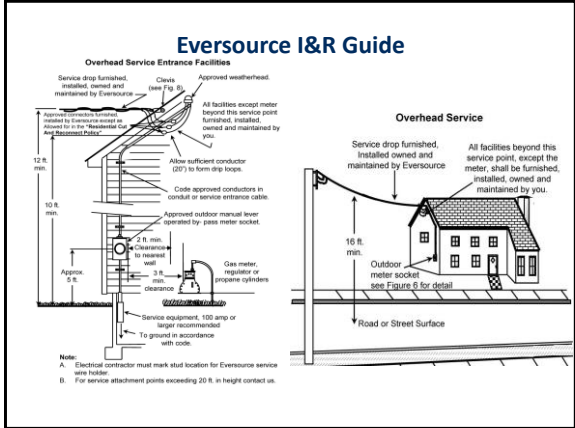
Service Address: _____

OK	NG	N/A	#	Item**	NFPA 70- 2014 NEC*
General					
				2016 Connecticut State Building Code	
				2012 IBC 105.0 or 2012 IRC R105.0	
Service Drop					
			1	Obtain electrical permits and utility approval	
			2	Minimum conductor sizes, (2011 NEC was 100A - #4 CU or #2 AL & 200A - 2/0 CU or 4/0 AL)	310.15(B)(7)
				Ampacity ≥ 83% of the service rating	310.15(B)(7)
				Ampacity ≥ 83% of the feeder rating	310.15(B)(7)
			3	Minimum open conductor clearance from doors or windows is 3 feet	230.9
				Unless above a window	Exception
			4	Minimum roof clearance is 8 feet	230.24(A)
				Reduction to 3 feet allowed for roof pitches ≥ 4:12	Exception 2
				Reduction to 18 inches above overhangs (≥ 6 feet horiz. above overhang)	Exception 3
			5	Minimum vertical ground clearance	230.24(B)
				10 feet from grade or sidewalks to lowest point of drip loop	230.24(B)(1)
				12 feet from grade over residential driveways	230.24(B)(2)
			6	Protect service entrance cables near driveways or where subject to damage	230.50
			7	Cable wall support within 12 inches of terminations & not over 30 inch intervals	230.51(A)
			8	Aluminum connections require anti-oxidant	110.3(B)
			9	Service head listed for wet locations required	230.54
			10	Locate weatherhead or gooseneck above service-drop attach point	230.54(C)
				Where impracticable, locate within 24 inches of attach point	Exception
			11	Formed drip loops and connections located below service head	230.54(F)

Grounding and Bonding					
			12	Minimum grounding electrode conductor size (AWG)	250.66
				100 Amp - #6 unprotected or #8 copper in raceway or armor	250.64(B) Table 250.66
				200 Amp - #4 copper to water pipe and #6 copper to ground rods	Table 250.66
				Aluminum conductors not allowed in contact with masonry or earth	250.64(A)
			13	Securely fasten and protect grounding electrode conductor from physical damage	250.64(B)
			14	Grounding electrode conductor attached within 5 feet of water pipe building entrance	250.68(C)
			15	Clean electrodes at the clamp connector to make a permanent, effective path	250.68(B)
			16	Two 8-foot long ground rods 8 ft. min. separation, upper end flush or below ground	250.53
			17	External intersystem bonding terminal at meter equipment or disconnect equipment	250.94
			18	Ground rod clamps suitable for direct burial & connect only one conductor	250.70
			19	All grounding electrode conductors must be brought to the service disconnect	250.24(C)
			20	No grounding connections on the load side of service disconnecting means	250.24(A)(5)
			21	Main bonding jumper (strap or green screw) to service disconnect enclosure	250.29
			22	Bond both ends of metal raceways containing grounding electrode conductors	250.64(E)
			23	Bonding jumper required across water meters and insulated joints	250.68(B)

Service Panel					
			24	Workspace in front of panel 30" w x 36" d x 78" h - See 110.26(A)(3) Exception 1	110.26
			25	Illumination of indoor working spaces about service equipment and panelboards	110.26(D)
			26	Service disconnect limited to six switches or breakers at one location	230.71(A)
			27	Service disconnect outside or inside at nearest point of entry of service conductors	230.70(A)
			28	Service disconnect permanently marked to identify it as a service disconnect	230.70(B)
			29	Circuit breakers or fuses identified on a circuit directory by the loads they supply	408.4
			30	Fuse or circuit-breaker panels prohibited in clothes closets or bathrooms	240.24(D)&(E)
			31	Circuit breakers are compatible with the panel as listed on the panel door	110.3(B)
			32	Unused openings in panels, raceways or boxes shall be properly closed	408.7 & 110.12(A)





SINGLE PHASE CONDUIT SYSTEM INSPECTION CHECKLIST

The installation is subject to inspection and approval by the Company to ensure that all items listed below are installed as specified. Please use this checklist to ensure compliance. The Company will not install its facilities if any of these requirements are not met.

N ^o	Y ^s	TRENCH / CONDUIT
		Min. 30" depth from finished grade to top of primary conduit.
		Min. 24" depth from finished grade to top of secondary conduit
		Conduit minimum size 3" diameter Schedule-40 PVC, electrical grade.
		Min. 18" clearance in all directions between electric conduits and adjacent water, sewer, fuel, (oil or gas) lines, and building foundations.
		1/4-inch diameter nylon pull line, including 10 ft. of slack, installed and secured in conduit with conduit plugs at both ends.
		Clean backfill (with less than 2" stones) on-site for backfilling entire trench, (inspector may witness backfilling).
		Warning Tape – spot check.
		Conduit run conforms to layout in construction plan.
		No parallel conduits or other facilities directly above electrical system conduits.
		RISER POLE
		90 degree galvanized steel bend installed as specified.
		Bend capped and secured to pole with pipe strap.
		Steel-PVC adapter and steel sweep not encased in concrete.
		Ground clamp and 6" ground conductor installed.
		Conduit riser located on field side of pole opposite direction of traffic.
		Riser path clear to top of pole.

***NOTE:** Y – Acceptable; N – Deficient

INSTALLATION IN TRENCH – All direct-buried cables shall be installed at a depth of at least 30 inches in the following order:

1. Ensure that the bottom of the trench is well-tamped and free of rocks.
2. Install the conduit, gluing all couplings.
3. Install secondaries and other utility cables or conduits in the trench.
4. Backfill with 12 inches clean fill not to contain stones larger than 2 inches in maximum diameter.
5. Install cable warning tape 12 inches over the conduit.
6. Fill in the remainder of the trench with native backfill.
7. Install pull line, including 10 feet of slack, and secure to conduit plug at each end of conduit run.

NATIVE BACKFILL NOTE 1

FINISHED GRADE

CAUTION TAPE 50'x 5" (6'x 5')

CLEAN FILL 12" Above installed pipe

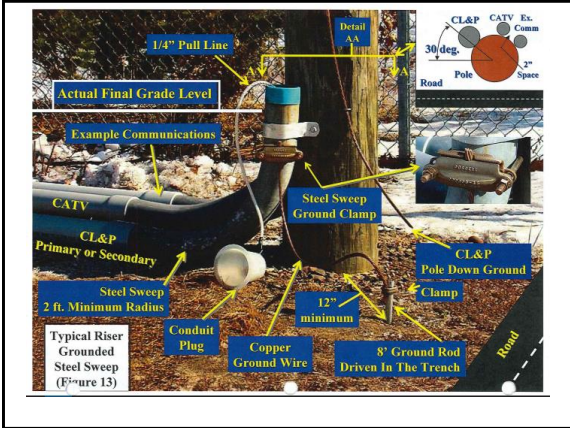
FUEL OR WATER LINE

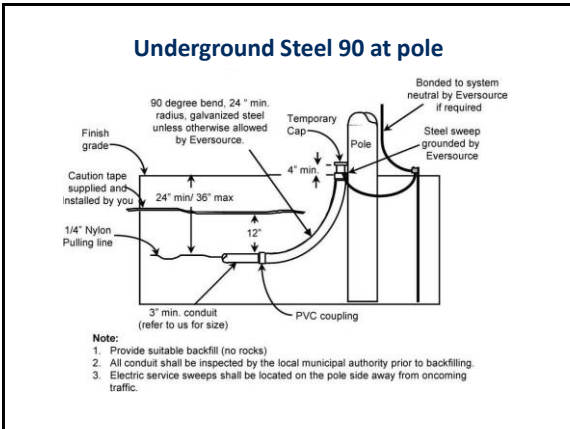
CONDUIT FOR PRIMARY CABLE (SCHEDULE 40 PVC)

(SECONDARIES AND/OR OTHER UTILITIES WITH OR WITHOUT CONDUIT)

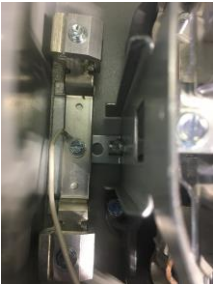
18" MIN. BALL DIRECTIONS







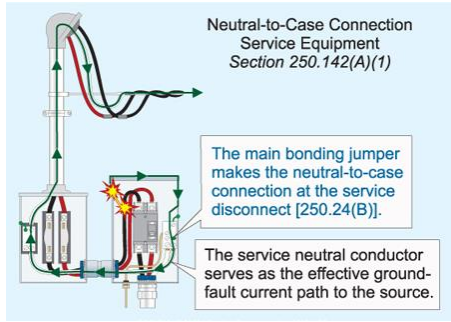
Service Raceways and Enclosures must be Bonded



250.80 Metal Enclosures (meter sockets, cold sequence meter disconnects, fire pump disconnect, troughs, nipples) and metal raceways, containing service conductors, MUST be bonded to the Service Neutral conductor.

Any metal installed AHEAD of the Main breaker.

Service Fault Current Path



Meter Enclosure bonding jumper



Meter



- Approved, listed in I&R book.
- Height 5' center.
- Line on top, Load on bottom.
- Proper screws to house. 110.13
- Bond to frame jumper 250.92
- Anti-oxidant on lugs(trade practice)
- Same size wire in and out, stripped back so wire is under lug.
- Terminals torqued.
- Watertight, sealed.
- Connector out bottom or out back to panel.

Service Panel (first means of disconnect)



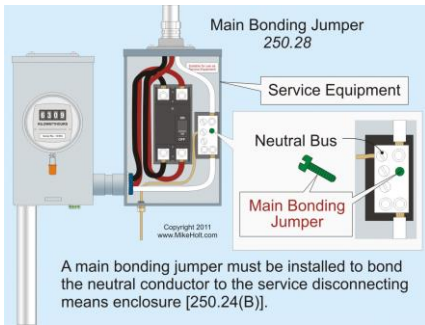
Main breaker, first means of disconnect, grounds and neutrals bonded together (and never again!) 250.24 (except on the 3 wire stove and dryer you still have 250.104).

230.70 A 1 "The service disconnecting means (main) shall be installed at a readily accessible location either outside of the building or structure, OR, inside nearest the point of entrance of the service conductors."

- A: Outside of the building or structure
- B: Inside nearest the point of entrance of the service conductors

230.6 "outside" is outside, not inside. 5 conditions are also considered "outside".

Grounds and Neutrals Bonded at Main



The Green Screw



Our House



Underground Service

Utility determines the Service Point

Customer owns (NEC covers) house side of service point.

Utility owns (NEC does not cover) utility side of service point.

Transfer of ownership to utility after service is energized.

Don't attach the conduit where it is supposed to move!



Electrical Service in our house


200 Amp
120/240v 1 phase
42 circuit panel

4/0 Aluminum
#4 to Grounding Electrode water (250.66)
#4 to ufer ground ?
#6 to rods



Note the receptacle at the panel- required?
210.64 Exception 1

What about a light?
210.70 C



Size does matter

230.42 (E3602.1) Service entrance conductors shall have ampacity of not less than the maximum load to be served.

310.15 B (7) (1)
Service conductors supplying entire load of SFD, ampacity of conductors to be 83% of service rating.

200 amp x 83% = 166 amp

Table 310.15 B (16) 75 degree column (due to terminal lug rating)
4/0 Aluminum = 180 amp

What about 100 amp service? 400 amp service?
Size printed on cable assembly or individual conductors 310.120

What's Confusing?

System Ground (grounding): The connection to earth (ground) of a power supply system.
Typically by connecting the grounded conductor to the grounding electrode at the point of Utility supply. GEC sized 250.66 (But not always: negative of a DC PV array, neutral of a separately derived system...)

Equipment Ground (bonding): Connecting all non-current carrying metal parts to earth (ground), typically run with the circuit conductors (but not always), equipment bonding jumper sized 250.122
metal enclosures, boxes, conduit, module frames...



Some Ground Rules Grounding vs Bonding

Grounding is Bonding
Bonding is not Grounding

Bonding – connecting together to establish electrical continuity and conductivity
Grounding – connecting to ground (the earth)

Grounding – green or bare
Grounded – dead- white or gray

250.52 Grounding Electrode

- A 1 Underground Metal Water Pipe** * 10' of pipe in direct contact with earth *
- A 2 Metal In-Ground (earth) Support Structure** (new 2017) piles 10' vertical
- A 3 Concrete Encased Electrode (Ufer)**- 20'- ½" rebar continuous OR #4 bare copper in 2" of concrete in footing or foundation in **direct** contact with earth (no vapor). (Building official to verify and tag?)
- A 4 Ground Ring Electrode**- encircle building 30" deep, min 20' #2 bare copper
- A 5 Rod and Pipe Electrode** * 5/8" x 8' , 45°, in ditch 30" deep *
- A 6 Listed Electrode**
- A 7 Plate Electrode** * 1ft x 1ft = 2ft² (two sides exposed to soil 30" deep) 250.53 H *
- A 8 Metal Underground System** well casing, tanks

Grounding and Bonding

	12- Minimum grounding electrode conductor size (AWG)		250.66
	100 Amp - #6 unprotected or #8 copper in raceway or armor	250.64(B)	<i>Table 250.66</i>
	200 Amp - #4 copper to water pipe and #6 copper to ground rods		<i>Table 250.66</i>
	Aluminum conductors not allowed in contact with masonry or earth		250.64(A)
	13- Securely fasten and protect grounding electrode conductor from physical damage		250.64(B)
	14- Grounding electrode conductor attached within 5 feet of water pipe building entrance		250.68(C)
	15- Clean electrodes at the clamp connector to make a permanent, effective path		250.68(B)
	16- Two 8-foot long ground rods 6 ft. min. separation, upper end flush or below ground		250.53
	17- External intersystem bonding terminal at meter equipment or disconnect equipment		250.94
	18- Ground rod clamps suitable for direct burial & connect only one conductor		250.70
	19- All grounding electrode conductors must be brought to the service disconnect		250.24(C)
	20- No grounding connections on the load side of service disconnecting means		250.24(A)(5)
	21- Main bonding jumper (strap or green screw) to service disconnect enclosure		250.28
	22- Bond both ends of metal raceways containing grounding electrode conductors		250.64(E)
	23- Bonding jumper required across water meters and insulated joints		250.68(B)



Ufer Ground

250.52 A (3) concrete-encased electrode

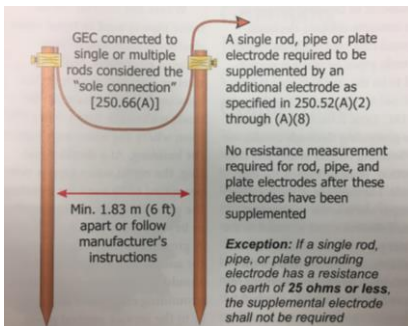


Water Line as Grounding Electrode

Jump the Meter to Bond water system



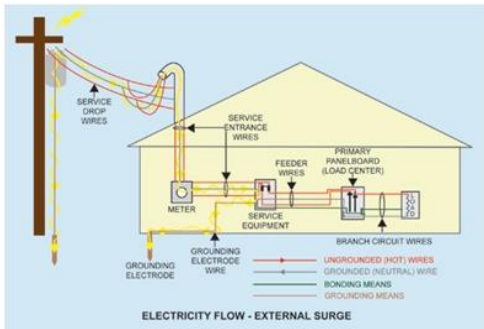
Drive One, Drive Two



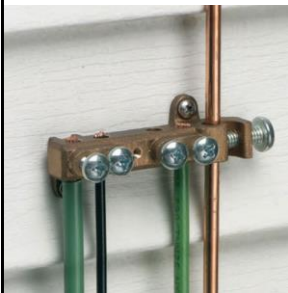
CT Amendment

(Amd) **250.50 Grounding Electrode System.** If available on the premises at each *building* or structure served, each item in 250.52 (A)(1) to (A)(7), inclusive, shall be bonded together to form the grounding electrode system. Where none of these grounding electrodes are available, one or more of the grounding electrodes specified in 250.52 (A)(4) to (A)(8), inclusive, *shall* be installed and used.

Path for Lightning



250.94 Intersystem Bonding



- #6 to terminal
- Bond communication systems
- Accessible
- Required for new services
- Not** required for service changes on existing buildings.

Bond the Black Iron with #6

250.104 B



PV Installation



AC Disconnect

Inverter

PV Disconnect

TESLA

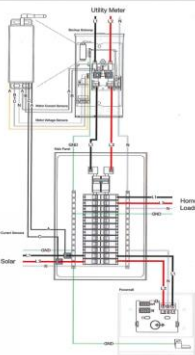
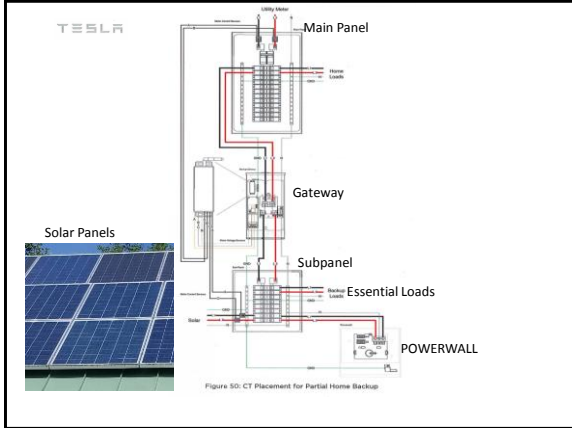


Figure 49: CT Placement for Whole Home Backup





After those fires, Walmart decided it had had enough. *“To state the obvious,”* the complaint said, *“properly designed, installed, inspected and maintained solar systems do not spontaneously combust.”*

The retailer demanded that Tesla disconnect the solar panels installed on its stores, the complaint said, and Tesla agreed that “de-energization” would be prudent.

But last November, the roof of a Walmart in Yuba City, Calif., *ignited*. When the blaze was discovered, wires on the roof were still sparking, the complaint said, *even though the solar panels had been disconnected for five months.*




Among the problems Walmart claims to have identified:

- "Many of the Tesla solar panels inspected by Walmart were suffering from hotspots, resulting in **cracking of the back sheets on solar modules** and compromising electrical insulation."
- "Making matters worse, Tesla had flagged or identified hotspots by placing pieces of tape over the affected areas. Because this tape prevented sunlight from reaching the solar panel, it exacerbated the problem by further concentrating heat."
- "Tesla teams consistently **failed to torque** (or tighten) field-made connectors." "The lack of torquing leads to moisture and water intrusion."
- "Sharp points—from, among other items, **rough concrete or metal edges**—were **cutting into the wires**. In other cases, temperature changes resulted in the expansion and contraction of wires over time, moving the wires and resulting in their abrasion or exposure."
- Multiple sites had **improper grounding**.

- ### PV Field Inspection Checklist
- a) Array matches plans
 - b) Wire Management
 - c) Module and Array Grounding
 - d) Electrical enclosures on Roof Accessible and Connections Suitable for the Environment
 - e) Array Fastened and Sealed According To Attachment Detail
 - f) Conductor Ratings and Sizes

Array matches plan

1. Changing the array wiring layout without changing the submitted electrical diagram.
2. Changing the module type or manufacturer as a result of supply issues.
3. Exceeding the inverter or module voltage due to improper array design.
4. Putting too few modules in series for proper operation of the inverter during high summer array temperatures.

Wire Management



Common Equipment Ground Installation Violations

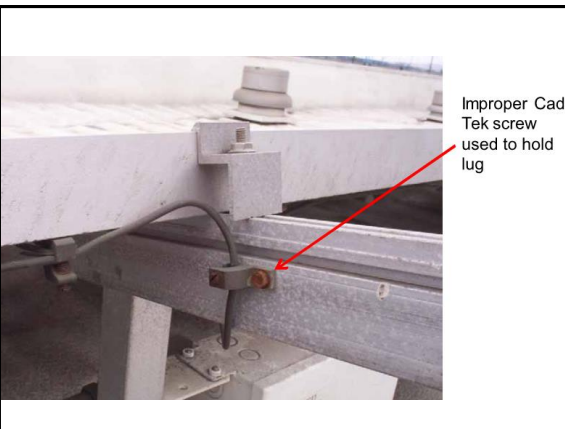
1. Not installing a grounding conductor on the array at all.
2. Using cad-plated Tek screws to fasten ground wires or lugs to modules.
3. Using indoor-rated grounding lugs on PV modules and support structures.
4. Not protecting EGCs smaller than 6 AWG from physical damage.
5. Allowing copper EGC to come in contact with the aluminum rails and module frames.
6. Assuming that simply bolting aluminum frames to support structures provides effective grounding.

Indoor lugs and Tek screws

Aluminum bolted to steel without isolation washers and no effective bond



Improper Cad Tek screw used to hold lug



Grounding and Bonding

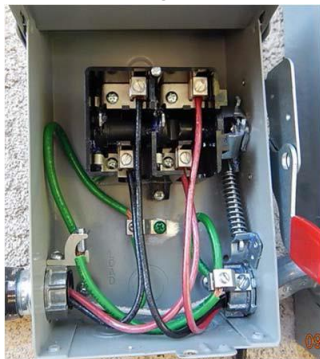
Improperly seated WEEB



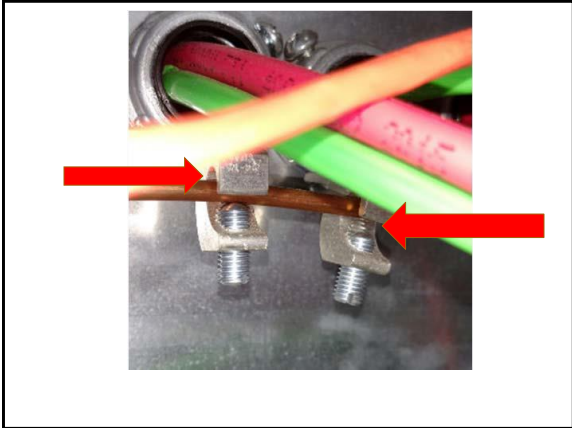
What to Look For:

- | | |
|--|---|
| 250.12
Clean Surface/ Contact point | Shiny metal, scrape marks,
tapped threads (no TEK screw),
doesn't roll around pipe or rod |
| 110.14 A
Terminals, ONE CONDUCTOR
(more than 1 wire term to be
identified)
good connection without
damaging conductors. | All strands under lug, strands
not damaged, 1 wire/ lug
1 Acorn/ 1 Wire |
| 110.14 D (new 2017)
Installation, torquing values. | Not loose, can't pull them out |

Enclosure grounded



Scraped paint for lug
- good
Bonding bushing as
a locknut - not good



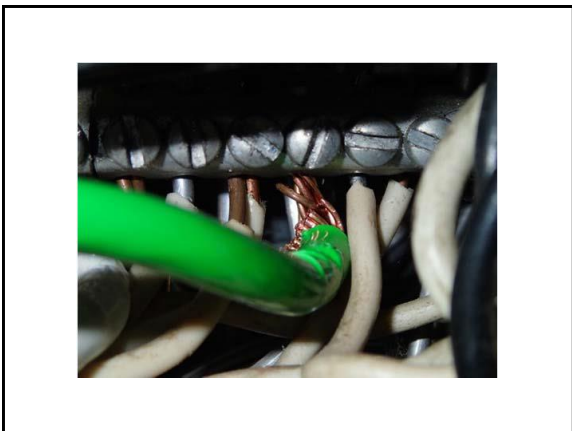




TABLE: SIGNAGE REQUIREMENTS FOR PV SYSTEMS

Code Section	Location of Label	Text
NEC 690.13(B)	On the PV system disconnect as identified in Figure 690.1(B)	PV SYSTEM DISCONNECT
NEC 690.13(B)	Disconnects with power on line and load terminals when in the open position	WARNING ELECTRIC SHOCK HAZARD TERMINALS ON THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION
NEC 690.53	On the DC disconnects	(1) Maximum voltage Informational Note to (1): See 690.7 for voltage (2) Maximum circuit current Informational Note to (2): See 690.8(A) for calculation of maximum circuit current. (3) Maximum rated output current of the charge controller or dc-to-dc converter (if installed)
NEC 690.54	At interactive points of interconnection, usually the main service	RATED AC OUTPUT CURRENT ___ AMPS NORMAL OPERATING AC VOLTAGE ___ VOLTS
NEC 690.56(B) 705.10	At the electrical service and at the PV inverter if not at the same location	A directory providing the location of the service disconnecting means and the photovoltaic system disconnecting means
NEC 690.56(C)	At the service disconnecting means	RAPID SHUTDOWN LABELS FOR TYPE OF SYSTEM INSTALLED

TABLE: SIGNAGE REQUIREMENTS FOR PV SYSTEMS

Code Section	Location of Label	Text
NEC 705.12(B)(2) (3)(b)	Inverter output OCPD	WARNING POWER SOURCE OUTPUT CONNECTION — DO NOT RELOCATE THIS OVERCURRENT DEVICE.
NEC 690.55	Battery enclosure	MAXIMUM OPERATING VOLTAGE, EQUALIZATION VOLTAGE POLARITY OF GROUNDED CONDUCTORS
IFC 605.11.1.4	On conduit, raceways, and enclosures, mark every 10 feet, at turns, above/below penetrations	WARNING PHOTOVOLTAIC POWER SOURCE
NEC 705.12(B)(3)	Equipment containing overcurrent devices in circuits supplying power to a busbar or conductor supplied from multiple sources shall be marked to indicate the presence of all sources.	Dual Power Source. Second source is a solar PV system.

SIGNS AND LABELS

Labels are phenolic where exposed to sunlight. Labels required on conduit are permanent, weather resistant and suitable for the environment. Labels have a red background with white lettering. The following labels are required as applicable:



Electrical Rough Inspection



In Any Room

- Proper box for application: fan 3 wire or smoke (422.18)
- Neutral for occ sensor, Identify white as current carrier (200.7)
- Draft stopping drilled holes (E3402)
- Box fill (314.16)
- Grounds are made up (250.148, E3908.13)
- Any point along the wall to be within 6' of a receptacle. (210.52A)
- Switch location (210.70)
- Cables 1 1/4" from edge of framing, thru holes, nail plates, inside corners (300.4)
- Support/Staples- 12" from box, 4 1/2' apart, flat, 1 cable, 2 cables, stackers (334.30)

Drill,
Baby,
Drill !!!



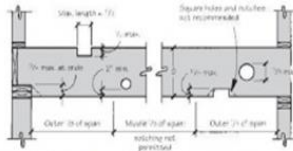


Solid wood framing

FRAMING GUIDELINES

Cutting, Notching, and Boring Lumber Joists

Joist Size	Maximum Hole	Maximum Notch Depth	Maximum End Notch
2x4	None	None	None
2x6	1 1/2"	1/4"	1 1/4"
2x8	2 1/8"	1 1/4"	1 1/4"
2x10	3"	1 1/2"	2 1/4"
2x12	3 1/4"	1 1/4"	2 1/4"



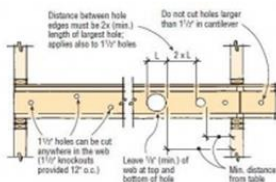
In joists, never cut holes closer than 2 inches to joist edges, nor make them larger than 1/3 the depth of the joist. Also, don't make notches in the middle third of a span, where the bending forces are greatest. They should also not be deeper than 1/3 the depth of the joist, or 1/4 the depth if the notch is at the end of the joist. Limit the length of notches to 1/3 of the joist's depth. Use actual, not nominal, dimensions. ("Field Guide to Common Framing Errors," 10/91)

I Joists Drilling and Notching



Rules for wood I-joists

Hole-Cutting Rules for Wood I-joists



Min. Distance from Inside Face of Support to Near Edge of Hole

Depth	T&E/Pro	2"	3"	4"	5"	6"
9 1/2"	150	1'-0"	1'-6"	3'-0"	5'-0"	6'-6"
	250	1'-0"	2'-6"	4'-0"	5'-6"	7'-6"
11 7/8"	150	1'-0"	1'-0"	1'-0"	2'-0"	3'-0"
	250	1'-0"	1'-0"	2'-0"	3'-0"	4'-6"
	350	1'-0"	2'-0"	3'-0"	4'-6"	5'-6"
	550	1'-0"	1'-6"	3'-0"	4'-6"	6'-0"
14"	250	1'-0"	1'-0"	1'-0"	1'-0"	1'-6"
	350	1'-0"	1'-0"	1'-0"	1'-6"	3'-0"
	550	1'-0"	1'-0"	1'-0"	2'-6"	4'-0"
16"	250	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"
	350	1'-0"	1'-0"	1'-0"	1'-0"	1'-0"
	550	1'-0"	1'-0"	1'-0"	1'-0"	2'-0"

General Notes:
 *Distance in the chart above is based on uniformly loaded joists using the steel truss brack shown (see T&E's brack). For other load conditions or hole configurations, contact T&E's representative.
 *For single span (5-foot maximum) uniformly loaded joists, one maximum hole may be located at the center of the joist span provided no other holes occur in the joist. DO NOT cut into joist flanges when cutting out web.

With wood I-joists and other types of engineered lumber, it's best to consult the manufacturer's literature. The example provided here is courtesy of Trus Joist MacMillan, ("Resipping With PEX," 10/99)



I-Joist Manufacturer Notes

NOTES:

1. Holes may be placed anywhere within the depth of the joist. A minimum 1/4" clear distance is required between the hole and the flanges.
2. Round holes up to 1-1/2" diameter may be placed anywhere in the web.
3. Perforated "knockouts" may be neglected when locating web holes.
4. Holes larger than 1-1/2" are not permitted in cantilevers without special engineering.
5. Multiple holes shall have a clear separation along the length of the joist of at least twice the length of the larger adjacent hole, or a minimum of 12" center-to-center, whichever is greater.

CT Amendment to NEC

(Add) 300.4.1 Drilling and notching.

(A) Structural floor, wall, ceiling and roof members.

(1) Solid sawn lumber.

Notches in solid lumber joists, rafters and beams shall not exceed one sixth of the depth of the member, shall not be longer than one-third of the depth of the member and shall not be located in the middle one-third of the span.

Notches at the ends of the member shall not exceed one-fourth the depth of the member. The tension side of members 4 inches or greater in nominal thickness shall not be notched except at the ends of the members.

The diameter of holes bored or cut into members shall not exceed one-third the depth of the member.

Holes shall not be closer than 2 inches to the top or bottom of the member, or to any other hole located in the member. Where the member is also notched, the hole shall not be closer than 2 inches to the notch.

Exception: Notches on cantilevered portions of rafters are permitted provided the dimension of the remaining portion of the rafter is not less than 4-inch nominal and the length of the cantilever does not exceed 24 inches.

CT Amendment

(2) **Engineered wood products.** Cuts, notches and holes bored in trusses, structural composite lumber, structural glue-laminated members or I-joists are **prohibited** except where permitted by the manufacturer's recommendations or where the effects of such alterations are specifically considered in the design of the member by a *registered design professional*.



CT Amendment

(3) Studs. Any stud in an *exterior wall* or interior bearing partition may be cut or notched to a depth not exceeding 25 percent of its width. Studs in nonbearing interior partitions may be notched to a depth not to exceed 40 percent of a single stud width. Any stud may be bored or drilled, provided that the diameter of the resulting hole is no greater than 40 percent of the stud width, the edge of the hole is no closer than 5/8 inch to the edge of the stud and the hole is not located in the same section as a cut or notch.

Exceptions:

1. A stud may be bored or drilled to a diameter not exceeding 60 per cent of its width, provided that such studs located in *exterior walls* or interior bearing partitions are doubled and not more than two successive studs are bored.
2. Approved stud shoes may be used when installed in accordance with the manufacturer's recommendations.

CT Amendment

(4) Top plates. When wiring, conduit, piping or ductwork is placed in or partly in an *exterior wall* or interior bearing wall, necessitating cutting, drilling or notching of the top plate by more than 50 percent of its width, a galvanized metal tie of not less than 0.054 inch thick (1.37 mm) (16 ga) and 1 inches (38 mm) wide shall be fastened across and to the plate at each side of the opening with not less than eight 10d (0.148 inch diameter) nails at each side or equivalent. The metal tie must extend a minimum of 6 inches past the opening.

Exception: When the entire side of the wall with the notch or cut is covered by wood structural panel sheathing.

Nail Plate



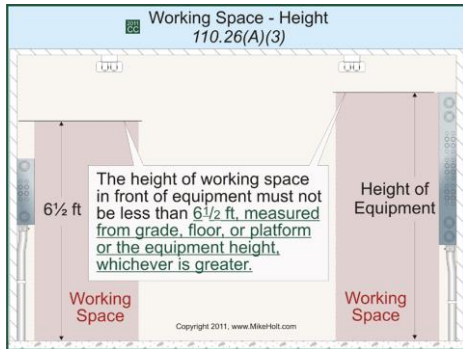
300.4 A 1 Protection

Edge of drilled *hole* is 1 ¼" or less – requires a nail plate – 1/16" thick - cover the width of the area

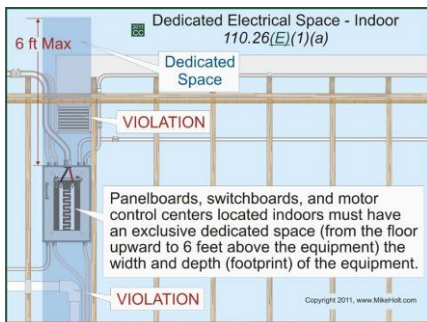
110.26 Working Clearance 30" x 3'



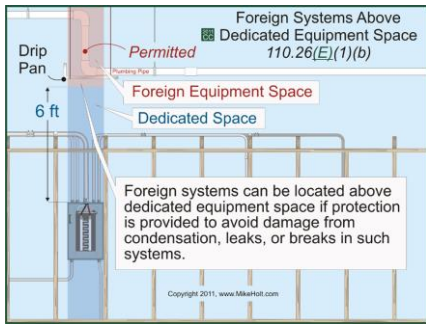
110.26 Working Space 30" x 3' x 6 1/2'



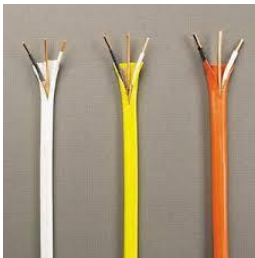
110.26 E 1 a Dedicated Space



Provide Protection

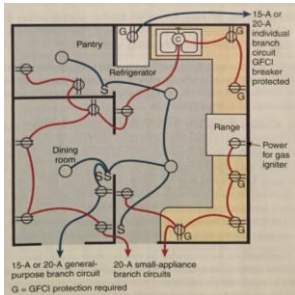


True Colors



White	14 AWG	15a
Yellow	12 AWG	20a
Orange	10 AWG	30a
Black	read it	
Gray	UF, SE	
60 degree C rating T 310.15(B)(16)		

**Kitchen circuits 210.52 B(1)Exception 2 (2017)
Receptacle to serve a specific appliance can be 15a**



Stack it



300.4 D Parallel to framing

“supported so that the nearest outside surface of the cable or raceway is not less than 1 ¼” from the nearest edge of the framing member “

Staples

SN 40 IB

1/2" Wide, 1" Long, Zinc Plated Low Carbon Steel, LDPE Blue Plastic Insulator



Armored Cable 14/2 And 14/3 Metal Clad 14/2 And 14/3
Non-metallic Sheathed 14/2 Through 10/3 Underground Feeder 14/2 And 12/2

CATALOG NUMBER	ULC # 780227	UNIT QUANTITY	MASTER CARTON	MASTER WEIGHT
SN 40 IB 100	780227	100	5000	51
SN 40 IB 500	780227	500	2500	25



SN 150 IB

1/2" Wide, 1-1/2" Long, Zinc Plated Low Carbon Steel, LDPE Red Plastic Insulator, Extra Long For Securing Up To Two Cables



One Cable Non-metallic Sheathed 14/2 Through 10/3 Underground Feeder 14/2 And 12/2
Two Cables Non-metallic Sheathed 14/2 Through 12/3 Underground Feeder 14/2 And 12/2

CATALOG NUMBER	UPC # 780227	UNIT QUANTITY	MASTER CARTON	MASTER WEIGHT
SN 150 IB 100	780227	100	5000	51
SN 150 IB 250	780228	250	2500	25
SN 150 IB 3M	780228	3000	BUCKET	29



SN 40 IB Staples



SN 150 Staples





314.17 C Exception



334.30 Support of NM cable

12" from every box
4 1/2' intervals along length

314.17 C exception

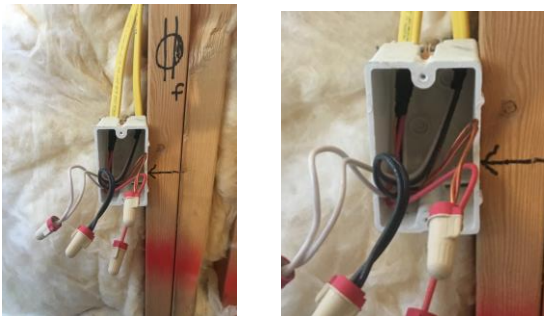
Single gang box with no clamps
(smash the knockout out), NM
cable 1/4" inside box, stapled 8"
from box.

Type of box for application



- 314.27 A (2)
Box listed to support weight:
- Fixture/ luminaire up to 50lbs
- Paddle Fan (314.27 C)
- Chandelier over 50lbs, listed, support independently of box
- Pendant

Box Fill? And Grounds must be continuous



Final Inspection

Final Inspection



Proper labeling of Directory at Panel 408.4

Clearance in front and around Panel, light in panel area 110.26

Receptacle in area to be serviced 210.64

Rough or Final Inspection?



314.20 Flush Mounted

314.22 Surface Extension

What is the finish surface?

Noncombustible ¼" Tile, gypsum (sheetrock)

Combustible Flush Wood, fabric, wallpaper



Finished Surface

314.20 Installations within or behind a surface of concrete, tile, gypsum, plaster or other noncombustible material, SHALL BE MADE so that the front edge of the box will not be set back of the finished surface more than ¼".

Installation within a surface of wood or other combustible material, box shall extend to the finished surface.

314.21 Noncombustible surfaces that are broken OR incomplete around boxes employing a flush-type cover or faceplate SHALL BE REPAIRED so there will be no gaps or open spaces greater than 1/8" at the edge of the box.



Final Inspection



406.6 Faceplates seat against surface



Final Inspection



Test receptacles for proper operation and Polarity 200.10

Grounding Type 406.4 A

Secured 314.23
6-32 machine screw 406.5

Tamper Proof 406.12

GFCI, AFCI location 210.8, 210.12

Finish flush with surface 314.19, 314.20, 314.21, 406.5, 406.6

Outdoor Receptacle



Wet Location 406.9 B
(E4002.9)

15 and 20 amp 125v
receptacle to be **WR** type

Weatherproof enclosure
regardless if plug is inserted

Extra Duty type

GFCI protected



Final Inspection



Testing of Smoke Detectors/
CO detectors IRC R314/ R315

Interconnected R314.4

AFCI *is* required for bedroom
smoke circuits 210.12 A

Only a fire alarm system is exempt
from AFCI protection

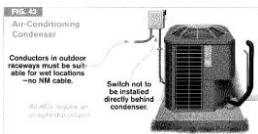
AC/DC

Final Inspection



Service switches for fixed
appliances

- Oil Burners and Furnaces
- Gas Burners
- AC Air handlers
- AC Compressors
- AC Split Systems
- Water Heaters
- Water pump



NEC 410.16
Air-Conditioning
Condenser
Conductors in outdoor
raceways must be suit-
able for wet locations
-no NM cable.
All A/C require an
emergency disconnect.

Switch not to
be installed
directly behind
condenser.

What could happen?





Use of OEDM Training Materials

Use of Office of Education and Data Management (OEDM) training materials must be approved in writing by the State of Connecticut, Department of Administrative Services' Office of Communications. In approving of such use, the State of Connecticut assumes no liability associated with such use, including, but not limited to, the user's dissemination of any inaccurate information or interpretation in connection with its use of these training materials. Use of the training materials is at the sole risk of the user, and the State's approval of the use does not constitute an endorsement of the user or its intended use.

