



COUNTY OF SANTA CRUZ

PLANNING DEPARTMENT

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County of Santa Cruz Inspection Checklist for Rooftop Photovoltaic Systems per 2013 CEC

Section 1: PV Array Configuration

- Module manufacturer, make, model, and number of modules match the approved plans. (CBC 107.4)
- PV modules are listed to UL 1703. (CEC 110.3, CBC 1509.7.4 & CRC R908.1.5) NOTE: AC modules need to be listed to UL 1703 and UL 1741.
- DC modules are properly marked and labeled. (CEC 110.3, 690.4(D) & 690.51)
- AC modules are properly marked and labeled. (CEC 110.3, 690.4(D) & 690.52)
- Modules are attached to the mounting structure according to the manufacturer's instructions and the approved plans. (CEC 110.3(A) & (B), CBC 107.4 & CRC R908.1.4)
- Roof penetrations are flashed and counter-flashed. (CBC Chapter 15 & CRC Chapter 9)
- PV modules are in good condition (i.e., no broken glass or cells, no discoloration, frames not damaged, etc.). (CEC 110.12(B))
- Residential one and two family dwelling limited to maximum PV system voltage of 600 volts. (CEC 690.7)
- Rooftop systems are designed in accordance with the CBC 1509.7 & CRC R908.1
- Roof access points, paths and clearances need to comply with the CRC R331.4.1 through R331.4.2.4

Section 2: Grounding

- A complete grounding electrode system is installed. (CEC 690.47(A),(B) & (C))
- Modules are grounded in accordance with manufacturer's installation instructions using the supplied hardware or listed equipment specified in the instructions and identified for the environment, and using the grounding point identified on the module and in the manufacturer's instructions. (CEC 690.43 & 110.3(B))

- Properly sized equipment grounding conductor is routed with the circuit conductors. (CEC 690.45, 250.134(B) & 300.3(B))
- AC and DC grounding electrode conductors are properly connected. Separate electrodes, if used, are bonded together. (CEC 690.47, 250.50 & 250.58)
- Bonding fittings are used on concentric/eccentric knockouts with metal conduits for circuits over 250 volts. (CEC 250.97) (see also exceptions 1 through 4)
- Bonding fittings are used for ferrous metal conduits enclosing grounding electrode conductors. (CEC 250.64(E))

Section 3: Wire Management

- Wires are secured by staples, cable ties, straps, hangers or similar fittings at intervals that do not exceed 4.5 feet. (CEC 334.30 & 338.12(A)(3))
- Wires are secured within 12 inches of each box, cabinet, conduit body or other termination. (CEC 334.30 & 338.12(A)(3))
- DC cable closely follows the surface of the building finish or of the running boards. (CEC 690.4(F), CRC R331.3)
- Where subject to physical damage conductors shall be protected. (CEC 300.4)

Section 4: Conductors

- Cable listed as type USE-2 or listed PV wire shall be permitted in exposed outdoor locations. (CEC 690.31(B)) If the cable is in conduit outdoors, the cable shall be wet rated. (CEC 300.9)
- Exposed single conductors used for ungrounded (transformerless) systems are listed and identified as "PV wire." (CEC 690.35(D)(3))
- Conductor insulation is rated at 90°C to allow for operation at 70°C near modules. (CEC 310.15(A)(3))
- Where conductors or cables are installed in conduits exposed to direct sunlight on or above rooftops, correction factors for ambient temperature adjustments are applied. (CEC Table 310.15(B)(2)(a) & Table 310.15(B)(3)(c))
- Grounded conductor is identified white or grey. (CEC 200.6(A))
- DC conductors inside a building are in a metal raceway or MC metal-clad cable that complies with metal enclosures. (CEC 690.31(E) & 250.118(10))
- If more than one nominal voltage system is installed in the raceway, permanent identification and grouping shall be required. Photovoltaic conductors shall not be contained within the same raceways with conductors, feeders, or branch circuits of other non-PV systems.(CEC 690.4(B)(1) –(4))
- For underground conductor installations in conduit, the burial depth shall be appropriate to conduit type. (CEC Table 300.5)

- Aluminum or copper-clad aluminum conductors shall not be placed in direct contact with the earth or concrete. (CEC 250.120(B) & 110.11)
- DC circuit conductors shall be sized to carry not less than the larger of 690.8(B)(2)(a) or (2)(b). The conductor ampacity shall be either 125% of the values calculated in 690.8(A) or the maximum currents calculated in 690.8(A) after conditions of use. (CEC 690.8(B)(2))

Section 5: Overcurrent Protection

- Over current devices in the DC circuits are listed for DC operation. (CEC 110.3(A), (B) & 690.9(D))
- DC source circuit overcurrent protection devices are rated at $1.25 \times 1.25 = 156\%$ short-circuit (ISC) current from modules. NOTE: The module ISC x number of combined strings, if strings are combined. When DC source circuits (strings) are connected in parallel the short circuit current multiplies DC overcurrent protective devices need to be sized appropriately. (CEC 690.8(B)(1))
- Inverter output circuit overcurrent protection device (point of connection to AC system breaker) is sized based on the maximum inverter output current x 125%. (CEC 690.8(A)(3) & 690.8(B)(1))
- Overcurrent protection is required for the PV source circuit (modules and parallel connected modules), PV output circuit (conductors between source circuits and inverter), inverter output circuit, battery circuit conductors and equipment. (CEC 690.9(A))
- Where three or more strings are combined, a listed combiner box (UL1741) is used and fuses are required. When DC source circuits (strings) are connected in parallel, the current through a failed circuit can be the sum of the current connected from the other strings, therefore special consideration must be taken to ensure the sum of the total number of strings minus one does not exceed the module manufacturers series fuse rating, or conductor ampacity. (CEC 110.3(B), 690.9(A))
- When a back-fed breaker is used as a utility interconnection means, the breaker shall not read "line or load." (CEC 110.3(B), 705.12(D)(5))
- PV interconnect breaker is located at the opposite end of the bus from the main circuit or feeder connection location. (CEC 705.12(D)(7))

Section 6: Electrical Connections

- Crimp on terminals are listed and installed using a listed tool specified for use in crimping those specific crimps. (CEC 110.3(B) & 110.14)
- Pressure terminals are listed for the environment and tightened to manufacturer recommended torque specifications. (CEC 110.3(B), 110.11 & 110.14)
- Connectors are listed for the voltage of the system and have appropriate temperature and ampere ratings. (CEC 110.3(B) & 110.14)
- Twist on wire connectors are listed for the environment (i.e. wet, damp, direct burial, etc.) and installed per manufacturer's instructions. (CEC 110.11, 110.3(B), 110.14, 300.5(B) & 300.9)
- Power distribution blocks shall be listed. (CEC 314.28(E))

- Terminals containing more than one conductor are listed for multiple conductors. (CEC 110.14(A) & 110.3(B))
- Connectors and terminals used for fine strand conductors are listed for use with such conductors. (CEC 110.14(A) & 110.3(B))
- Connectors that are readily accessible and operating at over 30 volts require a tool for opening. (CEC 690.33(C))
- Electrical equipment shall be installed in a workman like manner. (CEC 110.3(B) & 110.12)
- Wiring and connections of inverters, PV source circuits, battery connections, etc., and all interconnections are performed by qualified personnel. (CEC 690.4(E))

Section 7: Charge Controllers

- Charge controller is listed to UL Standard 1741. (CEC 110.3 & 690.4(D))
- Exposed energized live parts of electrical equipment operating at 50 volts or more shall be protected against accidental contact by approved enclosures. (CEC 110.27 (A) (1) – (4))
- Diversion charge controllers that are used as the sole means of regulating charging of batteries have a second independent means of control to prevent overcharging. (CEC 690.72(B)(1))

Section 8: Disconnects

- Disconnects used in DC circuits are listed for DC operation. (CEC 110.3)
- Disconnects are installed for all current carrying conductors of the PV source. (CEC 690.13 - 690.14)
- Disconnects are installed for the PV equipment. NOTE: For inverters and other equipment that are energized from more than one source, the disconnecting means must be grouped and identified. (CEC 690.15)
- Disconnects and overcurrent protection are installed for all ungrounded conductors in ungrounded (transformerless) PV power systems. (CEC 240.15 (A) & 690.35 (A))

Section 9: Inverters

- Inverters are listed to UL 1741 for application and use (CEC 690.4(D))
- Point of source interconnection shall be made at a dedicated breaker or disconnect. (CEC 705.12(D)(1))
- Total rating of overcurrent devices supplying loadside panelboard bus shall not exceed 120% of the panel rating. (CEC 705.12(D)(2))

- Listed AC and DC disconnects and overcurrent protection are grouped and identified. (CEC 690.15)
- The protective plastic barrier in the inverter shall be re-installed between the AC, DC wiring and communication wires. (CEC 110.3(B) & 110.27(A))

Section 10: Batteries

- Storage batteries for dwellings have the cells connected to operate at less than 50 volts. (CEC 690.71(B)(1))
- Live parts of battery systems for dwellings are guarded to prevent accidental contact by persons or objects. (CEC 690.71(B)(2))
- Flexible battery cables are listed RHW or THW, 2/0 minimum for battery cell connections. (CEC 690.74) NOTE: welding cables, marine, locomotive (DLO), and automotive cables do not meet the current Electrical Code requirements. (CEC 110.3(A) & (B))
- Flexible battery cables do not leave the battery enclosure. (CEC 690.74 & 400.8)
- Flexible, fine strand cables are only be used with terminals, lugs, devices, and connectors that are listed and marked for such use. (CEC 690.31(F), 690.74, 110.3(B) & 110.14(A))
- Listed DC rated fuses or circuit breakers are used in battery circuits.(CEC 690.71(C))
- Cables to inverters, DC load centers, and/or charge controllers shall installed in approved raceways where the voltage is greater than 30 volts. (CEC 690.31(A) & 690.31(E))
- Ventilation provisions shall be made for sufficient diffusion and ventilation of the gases from the batteries to prevent explosion. Follow battery enclosure manufacturer's instructions for venting and conduit locations. (CEC 110.3(B), 480.9(A) & 480.10)
- A disconnect means is provided for all ungrounded conductors derived from a stationary battery system over 50 volts. (CEC 480.5 & 690.15) NOTE: see CEC 690.71(E) for additional service disconnecting means requirements for series connected battery circuits.

Section 11: Signs and Labels

- All interior and exterior DC conduit, enclosures, raceways, cable assemblies, junction boxes, combiner boxes, and disconnects are marked. (CEC 690.31(E)(3) & CRC R331.2)
- The markings on the conduits, raceways and cable assemblies are every 10 feet, within one foot of all turns or bends and within one foot above and below all penetrations of roof/ceiling assemblies, walls and barriers. (CEC 690.31(E)(4) CRC R331.2.4)
- Where PV circuits are embedded in built-up, laminate, or membrane roofing materials in roof areas not covered by PV modules and associated equipment, the location of circuits shall be clearly marked. (CEC 690.4(F))
- 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:

Table: Signage Requirements for PV systems

Code Section	Location of Label	Text
CEC 690.5(C)	Utility-interactive inverter & battery enclosure	WARNING: ELECTRIC SHOCK HAZARD IF A GROUND FAULT IS INDICATED, NORMALLY GROUNDED CONDUCTORS MAY BE UNGROUNDED AND ENERGIZED
CEC 690.35(F)	All enclosures with <u>ungrounded</u> circuits or devices which are energized and may be exposed during service	WARNING: ELECTRIC SHOCK HAZARD. THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED.
CEC 690.14(C)(2)	On the AC and DC disconnects	PHOTOVOLTAIC SYSTEM DISCONNECT
CEC 690.53 Continued: CEC 690.53	On the DC disconnects	OPERATING CURRENT ____ OPERATING VOLTAGE ____ MAXIMUM SYSTEM VOLTAGE ____ SHORT CIRCUIT CURRENT ____
CEC 690.54	At interactive points of interconnection, usually the main service	RATED AC OUTPUT CURRENT ____ AMPS NORMAL OPERATING AC VOLTAGE ____ VOLTS
CEC 690.56(B) 690.14(D)(4), 705.10 CEC 690.4(H)	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
CEC 690.17	On the DC disconnect and on any equipment that stays energized in the off position from the PV supply	WARNING! ELECTRIC SHOCK HAZARD. DO NOT TOUCH TERMINALS. TERMINALS ON BOTH THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.
CEC 690.64 & 705.12(D)(7)	Point of connection	WARNING: INVERTER OUTPUT CONNECTION DO NOT RELOCATE THIS OVERCURRENT DEVICE.
Code Section	Location of Label	Text
NEC 690.55	Battery enclosure	MAXIMUM OPERATING VOLTAGE, EQUALIZATION VOLTAGE POLARITY OF GROUNDED CONDUCTORS

Section 12: Fire Safety

- Rooftop mounted PV panels and modules have the proper fire classification rating. (CBC 1509.7.2)
- Rooftop DC Conduits are located as close as possible to the ridge or hip or valley and from the hip or valley as directly as possible to an outside wall to reduce trip hazards and maximize ventilation opportunities. (CRC R331.3)
- Conduit runs between sub arrays and to DC combiner boxes are installed in a manner that minimizes total amount of conduit on the roof by taking the shortest path from the array to the DC combiner box. (CRC R331.3)
- DC Combiner Boxes are located so that conduit runs are minimized in the pathways between arrays. (CRC 331.3)
- DC wiring in enclosed spaces in buildings is installed in metallic conduit or raceways. Conduit runs along the bottom of load bearing members. (CEC 690.4(F) & CRC R331.3)
- DC wiring methods shall not be installed within 25cm (10") of the roof decking or sheathing except where directly below the roof surface covered by the PV modules and associated equipment. (CEC 690.31(E)(1))
- All roofs have an access point that does not place ground ladders over openings such as windows or doors, are located at strong points of building construction, and in locations where the access point does not conflict with overhead obstructions such as tree limbs, wires, or signs. (CRC R331.4.1)
- Roofs with slopes greater than 2:12 have solar panel layouts that meet the following criteria: (some exceptions apply,)
 - Hip Roofs: Panels/modules are located so that there is a 3-foot wide clear access pathway from the eave to the ridge on each roof slope where panels/modules are located. (CRC R331.4.2.1)
 - Hips and Valleys: If panels/modules are placed on both sides of a hip or valley they are located no closer than 18 inches to a hip or valley. If the panels are located on only one side of a hip or valley that is of equal length, then the panels can be placed directly adjacent to the hip or valley. (CRC R 331.4.2.3)
 - Single Ridges: Panels/modules are located so that there are two 3-foot wide access pathways from the eave to the ridge on each roof slope where there are panels/modules installed. (CRC R331.4.2.2)
 - Ridges: Panels/modules are located no higher than 3 feet from the top of the ridge in order to allow for fire department smoke ventilation operations. (CRC R331.4.2.4)
 - Access pathways are located at a structurally sound location capable of supporting the load of fire fighters accessing the roof, 3 feet wide minimum. (CRC R331.4.2.1)