Inspection Guide for PV Systems

(For Rooftop Photovoltaic Systems meeting the Standard Plan)

This document has two sections. Neither section is all-inclusive as this document is simply a tool to aid the inspection process.

> SECTION 1 – Field Inspection Guide: The purpose of this section is to give the field inspector a single-page reminder of the most important items in a field inspection.
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> SECTION 2- Comprehensive Reference: This reference details items that may be relevant in the field inspection of rooftop PV systems that comply with the comprehensive or simplified versions of the "Solar PV Standard Plan." Not all items outlined in this section are relevant to each PV system. This inspection reference details most of the issues that relate to the PV system during the inspection process.

All California Electrical Code (CEC), California Residential Code (CRC), California Building Code (CBC) and California Fire Code (CFC) references are to the 2013 versions unless otherwise noted.

SECTION 1: Field Inspection Guide for Rooftop Photovoltaic (PV) Systems Standard Plan

Make sure all PV system AC/DC disconnects and circuit breakers are in the open position and verify the following.

1. All work done in a neat and workmanlike manner (CEC 110.12).
2. PV module model number, quantity and location according to the approved plan.
3. Array mounting system and structural connections according to the approved plan.
4. Roof penetrations flashed/sealed according to the approved plan.
5. Array exposed conductors are properly secured supported and routed to prevent physical damage.
6. Conduit installation according to CRC R331.3 and CEC 690.4(F).
7. Firefighter access according to approved plan.
8. Roof-mounted PV systems have the required fire classification (CBC 1505.9 or CRC R902.4).
9. Grounding/bonding of rack and modules according to the manufacturer's installation instructions that are approved and listed.
10. Equipment installed, listed and labeled according to the approved plan (e.g., PV modules, DC/DC converters, combiners, inverters, disconnects, load centers and electrical service equipment).
11. For grid-connected systems, inverter is marked "utility interactive."
12. For ungrounded inverters, installation complies with CEC 690.35 requirements.
13. Conductors, cables and conduit types, sizes and markings according to the approved plan.
14. Overcurrent devices are the type and size according to the approved plan.
15. Disconnects according to the approved plan and properly located as required by the CEC.
16. Inverter output circuit breaker is located at opposite end of bus from utility supply at load center and/or service panelboard (not required if the sum of the inverter and utility supply circuit breakers is less than or equal to the panelboard bus rating).
17. PV system markings, labels and signs according to the approved plan.
18. Connection of the PV system to the grounding electrode system according to the approved plan.
19. Access and working space for operation and maintenance of PV equipment such as inverters, disconnecting means and panelboards (not required for PV modules) (CEC 110.26).

SECTION 2: Comprehensive Inspection Reference

GENERAL

1. Module manufacturer, make, model and number of modules match the approved plans. (CBC 107.4)
2. DC PV modules are listed to UL 1703. Ac modules are listed to UL 1703 and UL 1741. (CEC 110.3, 690.4 & CBC 1509.7.4 & CRC R908.1.5)
3. Modules are attached to the mounting structure according to the manufacturer's instructions and the approved plans. (CEC 110.3[B], CBC 107.4 & CRC R908.1.4)
4. Roof penetrations/attachments are properly flashed. (CBC Chapter 15 & 2012 CRC Chapter 9)
5. Rooftop systems are designed in accordance with the CBC. (CBC 1509.7 & CRC R908.1)
6. Roof access points, paths and clearances need to comply with the CFC. (CFC 605.11.3.1 - 605.11.3.3.3, CRC R331.4.1 through R331.4.2.4)
7. PV installation shall comply with requirements of the standard plan.
8. PV system operating at 80 volts or greater shall be protected by a listed DC arc fault protection. (CEC 690.11)
9. All work done in a neat and workmanlike manner. (CEC 110.12)

ELECTRICAL REQUIREMENTS

PV Array Configuration

10. DC modules are properly marked and labeled. (CEC 110.3, 690.4[D] & 690.51)
11. AC modules are properly marked and labeled. (CEC 110.3, 690.4[D] & 690.52)
12. PV modules are in good condition (i.e., no broken glass or cells, no discoloration, frames not damaged, etc.). (CEC 110.12[B])
13. Residential one- and two-family dwelling limited to maximum PV system voltage of 600 volts. (CEC 690.7)

Bonding and grounding

14. A complete grounding electrode system is installed. (CEC 690.47[A] & [B])
15. Modules are bonded and grounded in accordance with the manufacturer's installation instructions, that are listed and approved, using the supplied hardware or listed equipment specified in the instructions and identified for the environment. (CEC 690.43 & 110.3[B])
16. Racking systems are bonded and grounded in accordance with the manufacturer's installation instructions, that are listed and approved, using the supplied hardware or listed equipment specified in the instructions and identified for the environment. (CEC 690.43 & 110.3[B])
17. Properly sized equipment grounding conductor is routed with the circuit conductors. (CEC 690.45, 250.134[B] & 300.3[B])
18. AC and DC grounding electrode conductors are properly connected as required by code. Separate electrodes, if used, are bonded together. (CEC 690.47, 250.50 & 250.58)

19. 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)

20. Bonding fittings are used for ferrous metal conduits enclosing grounding electrode conductors. (CEC 250.64[E])

PV Source/output Circuit Conductor Management

21. Cables 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])

22. Cables are secured within 12 inches of each box, cabinet, conduit body or other termination. (CEC 334.30 & 338.12[A][3])

23. Cable closely follows the surface of the building finish or of the running boards. (CEC 690.4[F] & CFC 605.11.2 & CRC R331.3) NOTE: see Section 12 below for additional requirements on routing of conductors for fire fighter safety concerns.

24. Exposed single conductors, where subject to physical damage, are protected. (CEC 230.50[B] & 300.5[D])

25. Exposed single conductors used for ungrounded systems are listed and identified as "PV wire." (CEC 690.35[D][3]) For other conductor requirements for ungrounded systems, see CEC 690.35(D).

Conductors

26. Exposed single conductor wiring is a 90° C, wet rated and sunlight resistant type USE-2 or approved/listed PV wire. (CEC 690.31[B] & 110.2) If the wiring is in a conduit, it is 90° C, wet rated type RHW-2, THWN-
2, or XHHW-2. (CEC 310.15)

27. Conductor insulation is rated at 90° C to allow for operation at 70° C+ near modules. (CEC 310.15)

28. Grounded conductor is identified white or gray. (CEC 200.6)

29. Open conductors are supported, secured and protected. (CEC 338.12[A][3] & 334.30)

30. Conductors are not in contact with the roof surface. (CEC 334.30)

31. DC conductors inside a building are in a metal raceway or MC metal-clad cable that complies with 250.118(10), or metal enclosures. (CEC 690.31[E])

32. DC wiring methods shall not be installed within 25 cm (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])

33. If more than one nominal voltage system conductor is installed in the raceway, permanent identification and labeling is required. (CEC 200.6[D] & 210.5[C])

34. For underground conductor installations, the burial depth is appropriate and warning tape is in place. (CEC 300.5[D][3] & Table 300.5)

35. Aluminum is not placed in direct contact with concrete. (CEC 250.120[B] & 110.11)

36. PV circuit and premises wiring is separated. (CEC 690.4[B])

37. PV system conductors shall be grouped and identified. (CEC 690.4[B])

Overcurrent Protection

38. Overcurrent protection devices (OCPD) in the DC circuits are listed for DC operation. (CEC 110.3[A], [B] & 690.9[D])

39. Overcurrent protection devices shall be provided per the approved plans. (CEC 690.9[A])

40. Combiner box is listed to UL 1741.

41. PV output OCPD is located at the opposite end of the bus from the feeder connection, unless otherwise approved. (CEC 705.12[D][7])

Electrical Connections

42. Crimp terminals are listed and installed using a listed tool specified for use in crimping those specific crimps. (CEC 110.3[B] & 110.14)

43. Pressure terminals are listed for the environment and tightened to manufacturer recommended torque specifications. (CEC 110.11, 110.3[B] & 110.14)

44. Connectors are listed for the voltage of the system and have appropriate temperature and ampere ratings. (CEC 110.3[B] & 110.14)

45. 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])

46. Power distribution blocks are listed. (CEC 690.4 & 2011 NEC 314.28[E])

47. Terminals containing more than one conductor are listed for multiple conductors. (CEC 110.14[A] & 110.3[B])

48. Connectors and terminals used other than class B and C stranded conductors (fine stranded conductors) are listed and identified for use with specific conductor class or classes.. (CEC 110.14[A] & 110.3[B])

49. Connectors that are readily accessible and operating at over 30 volts require a tool for opening. (CEC 690.33[C])

50. All connectors are fully engages, tight and secure. (CEC 110.3[B] & 110.12)

51. Wiring and connections of inverters, PV source circuits, etc., and all interconnections are performed by qualified personnel. (CEC 690.4[E])

Disconnects

52. Disconnects used in DC circuits are listed for DC operation and located as allowed by the AHJ. (CEC 110.3)

53. Disconnects are installed for all current carrying conductors of the PV source. (CEC 690.13 - 690.14 & 690.35)

54. 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 per AHJ's requirements. (CEC 690.15)

55. Disconnects and overcurrent protection are installed for all ungrounded conductors in ungrounded PV power systems. (CEC 240.15 & 690.35)

56. Where connectors are used as disconnecting means, they shall be used in accordance with CEC 690.33.E (CEC 690.33.E & 690.17)

Inverters

57. Inverters are listed to UL 1741. (CEC 690.4[D]) NOTE: grid-tied system inverters need to be identified for use in interactive power systems.

58. Point of connection is at a dedicated breaker or disconnect. (CEC 705.12[D][1])

59. Where a back-fed breaker is used as a utility interconnection means, the breaker is not marked “line and load.” (CEC 110.3[B], 705.12[D][5])

60. Listed AC and DC disconnects and overcurrent protection are grouped and identified. (CEC 690.15)

61. No multiwire branch circuits are installed where single 120-volt inverters are connected to 120/240-volt load centers. (CEC 690.10[C])

62. The barrier is reinstalled between the AC, DC wiring and communication wires. (CEC 110.3[B] & 110.27)

Signs and Labels

63. All interior and exterior DC conduit, enclosures, raceways, cable assemblies, junction boxes, combiner boxes and disconnects are marked. (CFC 605.11.1, CEC 690.31[E][3], CEC 690.31[E][4], 690.17 & 690.53
& CRC R331.2)

64. 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. (CFC 605.11.1.4, CRC R331.2.4, CEC 690.31[E][3] & CEC 690.31[E][4])

65. Marking is placed adjacent to the main service disconnect in a location clearly visible from where the disconnect is operated. (CFC 605.11.1.3 & CRC R331.2.3)

66. The markings say “WARNING: PHOTOVOLTAIC POWER SOURCE” and have 3/8-inch (9.5 mm) minimum-sized white letters on a red background. The signs are made of reflective weather resistant material. (CFC 605.11.1.1, 605.11.1.2 & CRC R331.2.1 - R331.2.2 & CEC 690.31[E)][3] & 690.31[E][4])

67. 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])

68. Required labels shall be permanent and suitable for the environment. The following labels are required as applicable.

Table 1. 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 ungrounded 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)(1)	On the main service when DC wiring is run through the building and the DC disconnect is located other than at the main service	DC DISCONNECT IS LOCATED….
CEC 690.14(C)(2)	On the AC and DC disconnects	PHOTOVOLTAIC SYSTEM DISCONNECT
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 2011 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 705.12 (D)(7)	Inverter output OCPD	WARNING: INVERTER OUTPUT CONNECTION DO NOT RELOCATE THIS OVERCURRENT DEVICE.
CFC 605.11.1.4, CEC 690.31(E)(3), 690.31(E)(4), CRC R331.2.4	On conduit, raceways and enclosures, mark every 10 feet, at turns, above/ below penetrations	WARNING: PHOTOVOLTAIC POWER SOURCE. *Note: This label shall have a red background with white lettering*

FIRE SAFETY REQUIREMENTS

1. Rooftop-mounted PV panels and modules have the proper fire classification rating. (CBC 1509.7.2 & CRC R908.1.2)

2. Conduit, wiring systems and raceways for photovoltaic circuits are located as close as possible to the ridge, 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. (CFC 605.11.2 & CRC R331.3)

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. (CFC 605.11.2 & CRC R331.3)

4. DC Combiner Boxes are located so that conduit runs are minimized in the pathways between arrays. (CFC 605.11.2 & CRC 331.3)

5. DC wiring in enclosed spaces in buildings is installed in metallic conduit or raceways. Conduit runs along the bottom of load bearing members. (CFC 605.11.2 & CEC 690.4[F] & CRC R331.3)

6. 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. (CFC 605.11.3.1 & CRC R331.3)

7. Roofs with slopes greater than 2:12 have solar panel layouts with access pathways that comply with approved roof plan that meet the following criteria: (some exceptions apply, see diagrams in the California Solar Permitting Guidebook)

   A. 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. (CFC 605.11.3.2.1 & CRC R331.4.2.1)

   B. 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. (CFC 605.11.3.2.3 & CRC R 331.4.2.3)

   C. 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. (CFC 605.11.3.2.2 & CRC R331.4.2.2)

   D. 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. (CFC605.11.3.2.4 & CRC R331.4.2.4)

   E. Access pathways are located at a structurally sound location capable of supporting the load of fire fighters accessing the roof. (CFC 605.11.3.2.1 & CRC R331.4.2.1)

STRUCTURAL AND OTHER CODE REQUIREMENTS

List the structural requirements by the Authority Having Jurisdiction.