PV Arc Fault Protection

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PV Systems

- Unlike traditional electrical products PV modules and wiring **do not** have an overall enclosure to contain arcs and fires resulting from component or system faults.
- Are being installed in great numbers world wide.
- Are most often configured in high voltage series DC circuits.
- High voltage DC arcs are difficult to extinguish while energized.
- The number of PV system fires is increasing each year.
- PV systems need a mitigation means to protect from high voltage PV arcing faults.
- Solar ABCs, UL, PV BOS mfrs and AC AFCI mfrs work to develop a solution.

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Residential PV Arc and Fire 2/10/2009

Before the fire

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Residential PV Arc and Fire 2/10/2009

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BIPV Fire 3/8/2009

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PV Arc and Fire 4/5/2009

04/05/2009

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PV Arc and Fire 4/5/2009

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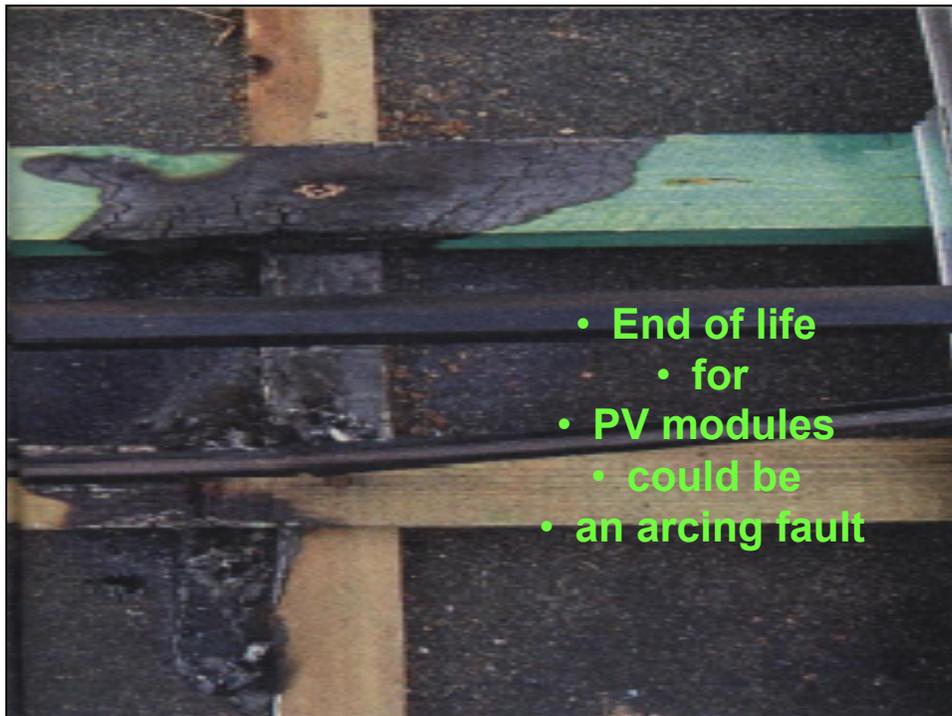
- End of life
- for
- PV modules
- could be
- an arcing fault

NEC 690.11 Is a New Requirement in the 2011 NEC

- It requires all PV systems with DC circuits operating at 80 volts or greater on a building to be protected by an AFCI, PV type, or other system components listed to provide equivalent protection.

- In parallel with this new NEC requirement, UL formed a PV AFCI Ad Hoc Working Group to develop requirements for the PV AFCI.

- UL Outline of Investigation, Subject 1699B, for PV AFCI equipment.

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690.11 Arc-Fault Circuit Protection

Required by NEC for:
- Photovoltaic systems with dc source circuits and or dc output circuits
- On or penetrating a building
- Operating at a PV max system voltage of ≥ 80 volts.

Compliance Criteria:
- Shall be protected by a **Listed**
  - PV/DC arc-fault circuit interrupter,
  - PV system components **Listed** to provide equivalent PV arc-fault protection

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NEC - PV AFCIs shall comply with the following:

(1) The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity (Series Arc Faults) of a conductor, connection, module, or other system component in the dc PV source and output circuits.

(2) The system shall disable or disconnect one of the following:

- a. Inverters or charge controllers connected to the fault circuit when the fault is detected
- b. System components within the arcing circuit

(3) The system shall require that the disabled or disconnected equipment be manually restarted.

(4) The system shall have an annunciator that provides a visual indication that the circuit interrupter has operated. This indication shall not reset automatically.

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PV AFCI Subject 1699B Update

- Well balanced Ad Hoc Working Group developing Subject 1699B Draft PV DC Arc-Fault Circuit Protection AFCI
- Most recent Ad Hoc Meeting at UL on Nov 30 and Dec 1, 2010.
  - Revise document to address Ad Hoc comments
  - Better address PV BOS equipment such as inverters or combiner boxes that include PV AVCI functionality
  - Upcoming publication Q1 2011.

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SU 1699B - PV DC Arc-Fault Circuit Protection AFCI

- Scope Includes:
  - Requirements cover DC photovoltaic arc-fault circuit protection devices for use in PV systems as described in Article 690 of the NEC.
  - Protection is intended to mitigate the effects of arcing faults that may pose a risk of fire.
  - Covers PV dc arc-fault circuit-interrupters (AFCI), arc-fault detectors (AFD), interrupting devices (ID) and
  - inverters, converters, and charge controllers with integral arc-fault circuit interrupter protection.
  - Rated up to 1000V dc.
  - Includes optional parallel tests but not required by 690.11

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Subject 1699B Tests

Humidity	**Corrosion Test**
Leakage	**Crushing**
Voltage surge	**Strain relief**
Environmental sequence	**Mechanical**
Arc fault detection	**Resistance to Environmental Noise**
Unwanted tripping	**Electrostatic discharge**
Inhibition	**Radiated EMI**
Temperature	**Fast transients**
Overvoltage	**Voltage surge**
Overload	**Induced RF fields**
Endurance	**Voltage dips**
Dielectric Withstand	**Surge current**
Abnormal	**Abnormal overvoltage**
Short circuit	

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Table 14.3
Arcing Tests and Clearing Times

Current (Amps)	Voltage (Volts)	Arcing (Watts)	Electrode Gap (Inches)	Clearing Time (Seconds)
7	43	300	1/16	2
7	71	500	3/16	1.5
14	46	650	1/8	1.2
14	64	900	¼	0.8

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Hey Wait a Minute!
PV AFCIs Are Not Here Yet!

- NEC 90.4 Enforcement
- The NEC includes a protection clause for new requirements when new protection products are not commercially available at the time of publication.

  - 90.4 This Code may require new products, constructions, or materials that may not yet be available at the time the Code is adopted. In such event, the authority having jurisdiction may permit the use of the products, constructions, or materials that comply with the most recent previous edition of this Code adopted by the jurisdiction.

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PV AFCIs are on the way!

- PV AFCIs and related components are being developed by many manufactures.
- In addition to stand alone PV AFCI products, the functionality is being built into many PV system components
  - Inverters
  - PV modules mounted electronics
  - PV DC/DC converters
  - Combiner Boxes

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UL Subject 1699B

- UL Subject 1699B will be used to evaluate and certify PV AFCI equipment.
- UL Subject 1699B is going be developed through the ANSI consensus standards writing process into ANSI / UL 1699B.
- UL is starting a new Standards Technical Panel (STP) for ANSI UL 1699B.
  - PV Industry, AFCI industry, Mfrs, AHJs, Test Labs, National Labs, Industry Experts, and General Interest.

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Questions?

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Distributed Energy Resources Equipment and Systems

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