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Photovoltaic DC Arc-Fault Circuit Protection and UL Subject 1699B

Tim Zgonena
UL LLC

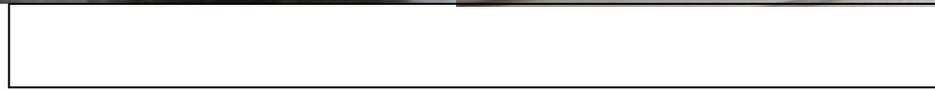
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PV Systems

- 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 are working to develop a solution.

J-box/Connector



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

UL Subject 1699B

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

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

Subject 1699B Tests

Humidity
Leakage
Voltage surge
Environmental sequence
Arc fault detection
Unwanted tripping
Inhibition
Temperature
Overvoltage
Overload
Endurance
Dielectric Withstand
Abnormal
Short circuit

Corrosion Test
Crushing
Strain relief
Mechanical
Resistance to Environmental Noise
Electrostatic discharge
Radiated EMI
Fast transients
Voltage surge
Induced RF fields
Voltage dips
Surge current
Abnormal overvoltage

Table 14.3 Arcing Tests and Clearing Times

Current (Amps)	Arcing Volts (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	1/4	0.8



PV Array



Arc Generator

UL1741

- A UL1741 CRD was published to require equipment that incorporates PV AVCI functionality to be evaluated for compliance with 1699B.

Some PV AFCI Products Are Listed Today and More 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

UL Listed PV AFCI Equipment

- Inverters

- **SMA SOLAR TECHNOLOGY AG**

- **Inverter with integral Type 1 PV AFCI Protection (high frequency),**
Models; SB2000HF-US-32, SB2500HF-US-32, SB3000HF-US-32,
- **Inverter with integral Type 1 PV AFCI Protection (transformer),**
Models; SB3000US-12, SB3800US-12, SB4000US-12, SB5000-
US-12, SB6000-US-12, SB7000-US-12, SB8000-US-12
- **Inverter with integral Type 1 PV AFCI Protection (transformer-less),**
Models; SB10000TLUS-12, SB11000TLUL-12, SB6000TLUS-12,
SB7000TLUS-12, SB8000TLUS-12, SB9000TLUS-12

- Standalone Detection Devices

- **EATON**

- PV ARCI Detector Module, Type 1, Model; PVG1A04V06B.

Ongoing 1699B Work

- We have discussed the need to perform more research testing at lower wattages and also at lower currents. We are also interested in collaborating with independent organizations who may have already conducted this research testing.

Ongoing 1699B Work

- We are working to develop additional test conditions including
 - Lower arc current
 - Lower arc power (watts)
 - Lower arc voltages
- An independent research organization has proposed a test with arcing current = 4A, arcing voltage = 25 volts and 100 arcing watts. We intend to research this proposal and determine its feasibility and assess the likelihood of fire at these values.
- Other tests are being proposed to mimic pin and sleeve PV connector arc faults.

Expansion of 1699B into the IEC

- TC82 WG 3/6 intends to keep the international PV AFCI requirements consistent and harmonized.
- To facilitate this effort, UL has authorized IEC TC82 to use UL Subject 1699B to speed in the development of the IEC PV AFCI Standard.

Proposals for 2014 NEC include

- Expansion to require PV AFCIs for all PV arrays (not just on buildings)
- To include parallel protection
- Public comments are being written now in preparation for the December 2012 ROC NEC meeting.



Questions?

Tim Zgonena

Principal Engineer

UL LLC