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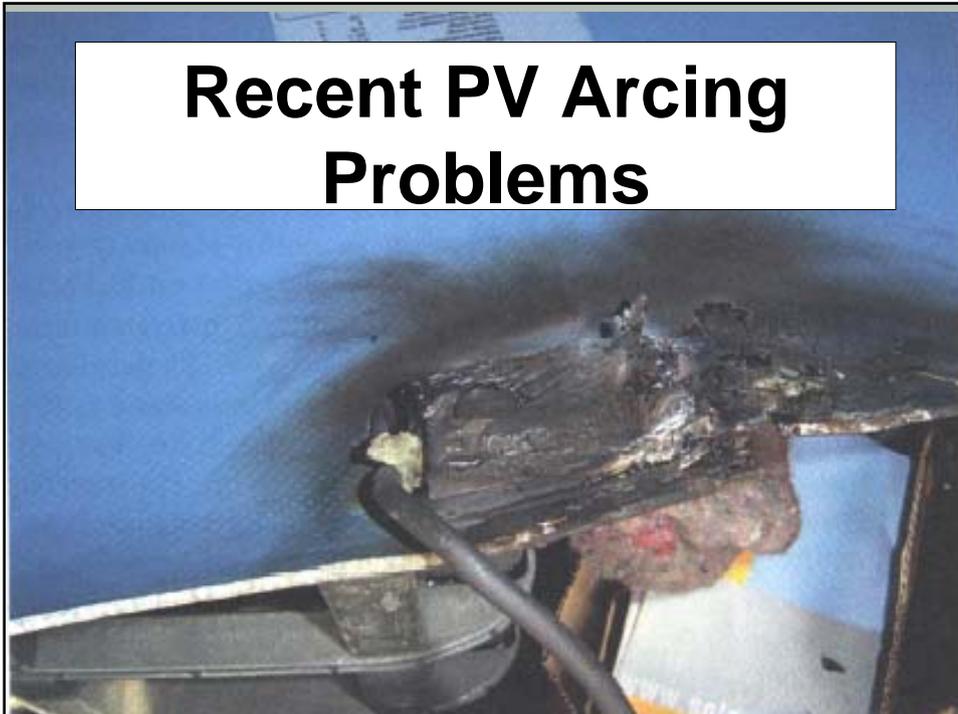
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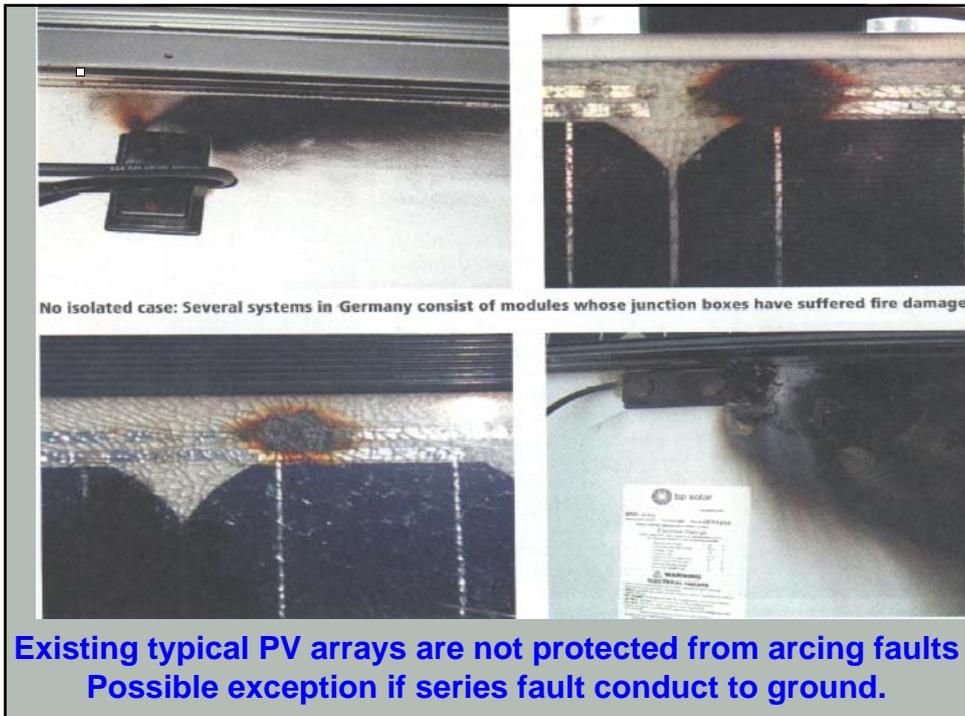
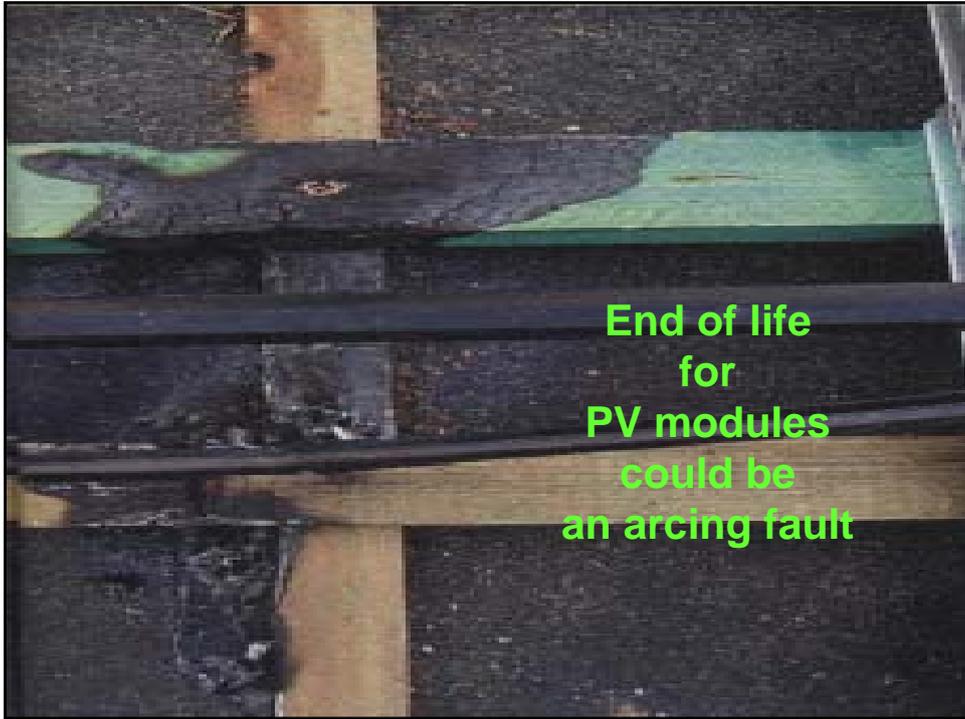
Solutions, State-of-the Art, and Missing Elements in Standards

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Underwriters Laboratories
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Arcing in PV DC-Arrays

Recent PV Arcing Problems







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IEC TC82 WG2 Meeting Tokyo 2006 Discussion and Actions

- Discuss PV module failures and potential fires resulting from arcing across bad solder connections near J-boxes.
- WG2 agreement to increase flame ratings for J-box potting compounds min V-1 to eliminate flaming drops of burning material.
- Proposal to develop PV Module Arcing test to fill **VOID**
- Creation of a new WG2 PV module materials project to define materials parameters.

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Series Arcing Faults

Series

- **When one of the current-carrying paths in series with the load is unintentionally broken or opened.**
- **Series arc faults could be mitigated by an inverter, charge controller or other load component with DC arc fault protection.**

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Parallel Arcing Faults

- When there is an unintentional conducting path between two conductors of opposite polarity. Often occurs when there is a failure of insulation between circuits
- This arc fault condition will be difficult to mitigate unless DC arc fault protection is located between the fault and array.

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Parallel AC Arc-Fault Damage

This is an example of damage to an electrical wire caused by arcing. The temperatures created by the arcing got so hot, it not only burned away the wire insulation, it welded two of the copper wires together.



Failures and fires due to PV arc faults have occurred





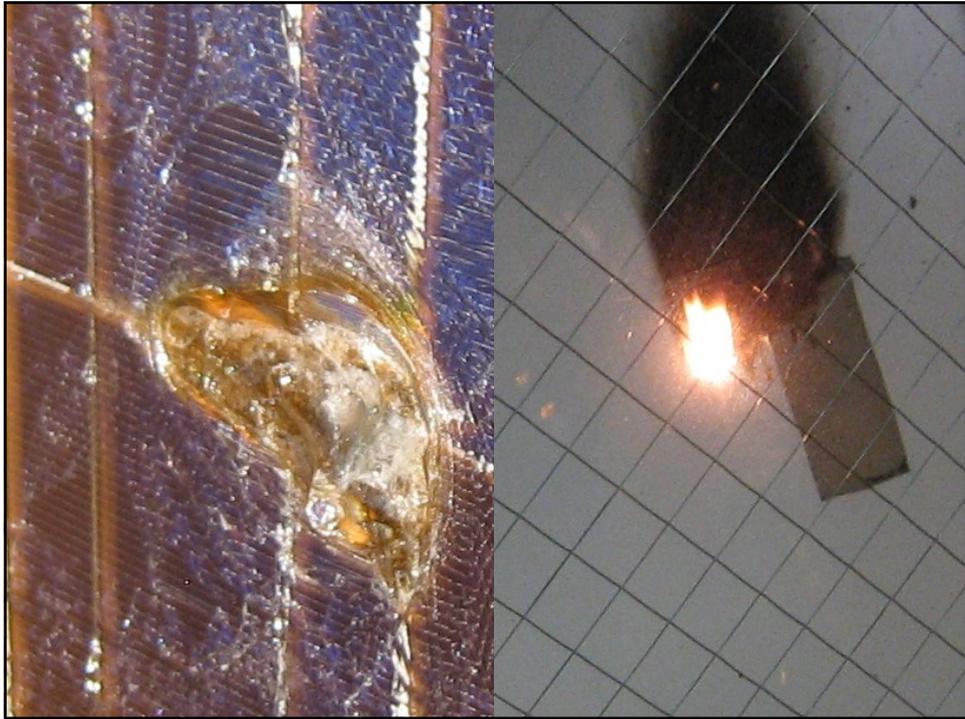
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UL R&D PV Module Series Arcing Test

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Many materials cannot withstand or contain arc faults

Module internal series arc test with diodes removed

- Localized burning of backsheet
- Glass superstrate shattered
- Localized glass melting
- Carbon coat surrounding area and allows easy restrike of arc
- Arc travels as “electrodes” are consumed



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Potential Issues

normal aging and long field life
physical stress
environment stress
corrosion
degradation of connections
degradation of components
degradation of materials

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What is an AFCI?

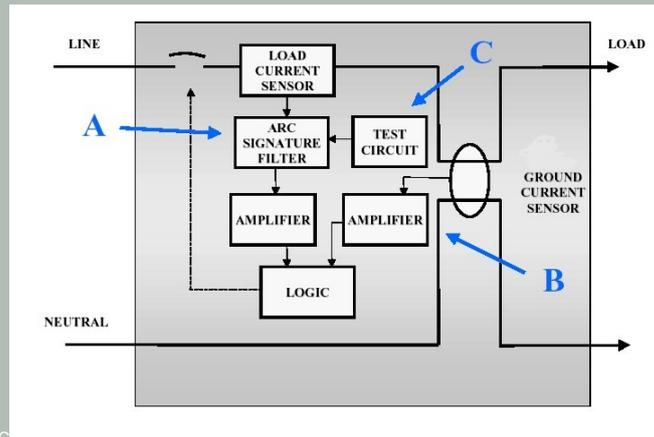
Arc-Fault Circuit Interrupter (AFCI)

A device intended to mitigate the effects of arcing faults by recognizing characteristics unique to arcing and de-energizing the circuit when an arc-fault is detected.

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The AFCI

Components in an Arc-fault Circuit Interrupters



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Issues related to DC Arc fault detection and interruption

- Determine where Arc detection would be needed
 - Then determine level of detection
 - Determine needs to avoid false trips
 - Determine needs/methods for PV array disable
 - Distinguish between series and parallel arcs
- Determine the requirements for ensuring the viability of the detection/interruption device

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Standards Needed

Safety Standard

- Construction
- Materials and components
- Trip Levels and Operation Parameters
- Failure modes
- Ratings, markings, installation and use instructions
- Manufacturing follow up and production line testing

Installation and System Standard

- When and where to be used in PV systems
- Ratings

PV AFCI US Work Plan

Literature research study on national and international documents to identify related issues

Will look at other industries and technologies to assess applicability and usefulness (aviation and naval)

Conclusions

- WG2 Increase PV module material requirements to minimize spreading of fire.
- WG2 potential develop PV module arcing test.
- PV AFCI protection requirements need to be developed.
- Under the US SAI we have a project to research PV arc faults, potential PV AFCI protection and develop requirements.
- **Electric Fire Is BAD!**



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