PV Module Frame Grounding

New Study Report

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Study Overview

- Address gap in requirements and methods for reliable grounding of PV module frame and mounting components

- Define grounding and bonding requirements
- Survey stakeholders and labs to address needs
- Develop test objectives and methods
- Ultimately incorporate in appropriate codes/ standards

Study Outline

1. Preliminary “lay-of-the-land” Report (BEW)
   - Summary of existing conditions, problem statement
   - Survey of existing issues and experiences from stakeholders
2. UL interim test development (UL)
   - Preliminary testing on corrosion, degradation using methods that go beyond those in existing UL1703 standard.
3. Final report (BEW/UL)
   - Recommendationsfor a set of tests/methods to incorporate into existing/new standards.

Preliminary Report

Existing State of Affairs

- Two Key Issues
  - Existing standards do not adequately ensure long term, reliable, and safe grounding of PV modules.
  - Standards lack guidance for evaluating alternative equipment or methods of PV module grounding
- Specific Issues/Consequences:
  - Field experience demonstrates listed module grounding methods can fail… tests not rigorous enough.
  - Onus of defining acceptable methods and components fall on module manufactures via UL 1703.
  - Grounding equipment suppliers must have their components/methods included in *module* installation manual

Preliminary Report

Existing State of Affairs

- UL 467 *Grounding and Bonding Equipment*
  - Has been used to list PV grounding equipment
  - Provides some useful tests but was not written to address unique aspects of PV system applications.
- Integrators and installers find *listed* methods to be limiting, unreliable, and costly – innovation is thwarted
- In practice, integrators, product developers, AHJs demonstrate widely different interpretations of acceptable means
- Various NRTLs interpret and impose requirements differently
- 2007 UL1703 CRD (Certification Requirements Decision) issued to clarify UL requirements – thwart NRTL evaluation of parts/methods not specified/tested by module manufacturer

Preliminary Report

Existing State of Affairs

- UL efforts to address problems
  - New more rigorous testing -- exploratory
  - Development of Std 2703 to address PV mounting systems
  - Scheduling of new series of STP (standards technical panel) meetings beginning in December --- key to affecting change
- Industry efforts to address problems
  - Work development through Solar ABCs
  - Proposal for standard language in UL 61730-1: PV Module Safety Qualification - Part 1
  - Proposal developed by group (Wiley, Bill Brooks, others) this week for review at STP meeting

Preliminary Report - Survey

- Most common failure modes
- Things that do work
- Installation issues (sensitivity to errors)
- Permitting issues
- Cost issues
- Needs and wishes
- Applicability of different codes and standards

Preliminary Report - Survey

- Most common failure modes
  - Loosening or failure of connections, corrosion
- Things that do work
  - Properly installed wire grounds, gas-tight mechanical module-module or support structure connections.
- Installation issues (sensitivity to errors)
  - Under or over-torqueing of wire/lug
  - Use of wrong parts or material
  - Insufficient penetration of coating on frames
- Permitting issues
  - Inconsistency of code/standard interpretation.
- Cost issues
  - Predominant wire-based methods very costly for large systems, e.g.

Preliminary Report - Survey

Installation issues (sensitivity to errors)

- Under or over-torqueing wire connections to frame ground holes
  - Under or over-torqueing lug connections to frame ground holes
  - Use of wrong material or lacking material (i.e. not per design)
  - Insufficient penetration of coating on frames, where that connection
- Permitting issues
  - Inconsistency of code/standard interpretation.
- Cost issues
- Predominant wire-based methods very costly for large systems, e.g.

Preliminary Report - Survey

Needs and wishes

- More approved methods utilizing abundant existing metal racking or support systems
- Standards uniformly applied (as opposed to module specific as defined in module installation manuals)
- More explicit use of mechanical mounting hardware. Criteria is that if a screw is used as ground current path, it can't be the (sole) mechanical connection.

Applicability of different codes and standards [NEC, UL 1703, UL 467, UL 1741, IEC 61730, etc..].

- Gap between 1703 and grounding and bonding. Lack of guidance for physical connections of frames and structures.
- UL 467 has good aspects, but some misses PV specific issues.
- Etc.

UL Interim Testing

Ongoing Corrosion Testing - Preliminary Report to be released soon:

- Involved numerous types of ground connectors
- Continuous damp heat and salt mist environmental exposure
- Periodic electrical current cycling.
- Measure change in resistance in connections.

Preliminary Results

- Salt mist condition, most samples corroded severely, failed in weeks
- Identical samples in damp heat chamber were still in good condition.
- Assembly force and anti-oxidant coating also have effects on integrity.
- Failure mechanisms from galvanic, pitting, and crevice corrosion
- Insulating metal oxide formed during the corrosion broke the electrical connections and failed the grounding system.

Tests Methods to Develop

- Resistance, component level
- Resistance, interconnected component level
- Current magnitude and duration (DC, AC)
  - Impulse current tests
  - Steady state current tests
  - Current cycling
- Accelerated lifetime tests
  - Temperature cycling with current cycling
  - Humidity with current cycling
  - Corrosive atmosphere exposure
- Mechanical Cycling
  - Vibration test

Other Work Planned

System Level Grounding

- AC modules and micro-inverters
- DC to DC converters
- Ground requirements to accommodate arc suppression
- GEC and/or equipment grounding conductors in the vicinity of the array
- Prescriptive mechanical interface requirements at system level to limit obviate need for listing all combinations of racking, framing, equipment, and bonding device

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