PV Module Frame Grounding

New Study Report
Greg Ball, BEW Engineering
Tim Zgonena, Underwriters Laboratories
October 30, 2009

PV Grounding Problems

- Improperly installed grounding hardware
- Dry-location lug rusting outdoors
- Dissimilar metals
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
- **Scheduled Report Publication Date: Dec 2010**
PV Module Frame Grounding

Specific Issues

- General requirements have lacked guidance (or options) for reliable bonding of modules and support structures
- Array level bonding outside of understood scope of UL1703
- Module install manuals often only cover one method
- In practice, integrators, product developers, AHJs demonstrate widely different interpretations of acceptable means
- NEC 2008/2011 expands on explicit use of mechanical components for grounding, provided they are tested/listed
- UL1703 2007 CRD expands on treatment dissimilar metals
- Debate on appropriate tests to qualify mounting hardware as equipment ground path (e.g. UL 1703, UL 467)
- Task: define procedures for acceptable reliable grounding methods validated by test methods and listings.

PV Module Frame Grounding

NEC 690.43 - 2011

Proposed Changes

- **(C) Structure as Equipment Grounding Conductor**, Devices listed and identified for grounding the metallic frames of PV modules or other equipment shall be permitted to bond the exposed metallic frames of PV modules metal surfaces or other equipment to mounting structures. Metallic mounting structures, other than building steel, used for grounding purposes shall be identified as equipment-grounding conductors or shall have identified bonding jumpers or devices connected between the separate metallic sections and shall be bonded to the grounding system.

Addresses racks and mounting devices that may used as equipment ground conductor if tested and identified as such.
NEC 690.43 - 2011
Proposed Changes (cont)

- **(D) PV Mounting Systems and Devices.** Devices and systems used for mounting PV modules that are also used to provide grounding of the module frames shall be identified for the purpose of grounding PV modules.

Addresses module mechanical fasteners that may be used for bonding/grounding if tested and identified as such.

The expanded statements serve two functions:
- Explicit acceptance of fasteners and structures as part of ground system
- Onus of listing to overcome difficulty of durable electrical contact with Al frames and other hardware.

---

**UL 1703 Dissimilar Metals CRD**

<table>
<thead>
<tr>
<th>Metal</th>
<th>Corrosion Resistance</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>90%</td>
<td>In soils and air, 85% in water.</td>
</tr>
<tr>
<td>Copper</td>
<td>90%</td>
<td>In soils and air, 85% in water.</td>
</tr>
<tr>
<td>Aluminum</td>
<td>90%</td>
<td>In soils and air, 85% in water.</td>
</tr>
<tr>
<td>Zinc</td>
<td>90%</td>
<td>In soils and air, 85% in water.</td>
</tr>
<tr>
<td>Copper, brass, bronze</td>
<td>90%</td>
<td>In soils and air, 85% in water.</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>90%</td>
<td>In soils and air, 85% in water.</td>
</tr>
<tr>
<td>Lead</td>
<td>90%</td>
<td>In soils and air, 85% in water.</td>
</tr>
<tr>
<td>Silver</td>
<td>90%</td>
<td>In soils and air, 85% in water.</td>
</tr>
</tbody>
</table>
Survey: Industry Experiences

- Standard methods
- Alternative methods
- Advantages and disadvantages of existing methods
  - Safety considerations
  - Long-term reliability
  - Installation issues (sensitivity to errors)
  - Cost (component and installation)
  - General applicability (across multiple products)
- Recommended Directions
- National lab input on life-time testing and reliability

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
Questions?

Greg Ball
BEW Engineering

Tim Zgonena
Underwriters Laboratories