

PV Module Frame Grounding

New Study Report

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PV Grounding Problems

Improperly installed grounding hardware



Dry-location lug rusting outdoors



Dissimilar metals



PV Grounding Problems

Corrosion in a harsh environment



This system is installed on an off-shore island of Taiwan for only 5 years

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PV Module Frame Grounding

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*

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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.*



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

0	0.05	0.55	0.7	0.8	0.85	0.9	1.0	1.05	1.1	1.15	1.25	1.35	1.4	1.45	1.6	1.65	1.7	1.75		
Magnesium, magnesium alloys																				
Zn																				
80 tin/20 Zn on steel, Zn on iron or steel																				
Aluminum																				
Cd on steel																				
Al/Mg alloy																				
Mild steel																				
Duralumin																				
Lead																				
Cr on steel, soft solder																				
Cr on Ni on steel, tin on steel, 12 % Cr stainless steel																				
High Cr stainless steel																				
Copper, copper alloys																				
Silver solder, Austenitic stainless steel																				
Ni on steel																				
Silver																				
tin, tin Ag on Cu, silver/gold alloy																				
Carbon																				
Cold, platinum																				
0	0.05	0.55	0.7	0.8	0.85	0.9	1.0	1.05	1.1	1.15	1.25	1.35	1.4	1.45	1.6	1.65	1.7	1.75	Magnesium, magnesium alloys	
0	0.05	0.2	0.3	0.35	0.4	0.5	0.55	0.6	0.65	0.75	0.85	0.9	0.95	1.1	1.15	1.2	1.25	1.25	Zinc, zinc alloys	
0	0.15	0.25	0.3	0.35	0.45	0.5	0.55	0.6	0.7	0.8	0.85	0.9	1.05	1.1	1.15	1.2	1.2	1.2	80 tin/20 Zn on steel, Zn on iron or steel	
0	0.1	0.15	0.2	0.3	0.35	0.4	0.45	0.55	0.65	0.7	0.75	0.8	0.95	1.0	1.05	1.0	1.05	1.05	Aluminum	
0	0.05	0.1	0.2	0.25	0.3	0.35	0.45	0.55	0.6	0.65	0.8	0.85	0.9	0.95	0.9	0.95	0.9	0.95	Cd on steel	
0	0.05	0.15	0.2	0.25	0.3	0.4	0.5	0.55	0.6	0.75	0.8	0.85	0.9	0.9	0.9	0.9	0.9	0.9	Al/Mg alloy	
0	0.1	0.15	0.2	0.25	0.35	0.45	0.5	0.55	0.7	0.75	0.8	0.85	0.85	0.85	0.85	0.85	0.85	0.85	Mild steel	
0	0.05	0.1	0.15	0.25	0.35	0.4	0.45	0.6	0.65	0.7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	Duralumin	
0	0.05	0.1	0.15	0.25	0.35	0.4	0.45	0.6	0.65	0.7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	Lead	
0	0.05	0.1	0.2	0.3	0.35	0.4	0.55	0.6	0.66	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	Cr on steel, soft solder	
0	0.05	0.15	0.25	0.3	0.35	0.5	0.55	0.6	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	Cr on Ni on steel, tin on steel, 12 % Cr stainless steel	
0	0.1	0.2	0.25	0.3	0.45	0.5	0.55	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	High Cr stainless steel	
0	0.1	0.15	0.2	0.35	0.4	0.45	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	Copper, copper alloys	
0	0.05	0.1	0.25	0.3	0.35	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	Silver solder, Austenitic stainless steel
0	0.05	0.2	0.25	0.3	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	Ni on steel
0	0.15	0.2	0.25	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	Silver
0	0.05	0.1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	

NOTE - Corrosion due to electrochemical action between dissimilar metals which are in contact is minimized if the combined electrochemical potential is below about 0.6 V.



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?

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