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How Standards Control Module Design for Better or Worse

2011 PV Module Reliability Workshop

John Wohlgemuth,

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Introduction

- PV Modules should be designed and constructed to perform in a safe manner outdoor for at least 20 or 25 years.
- However, it appears that many modules are designed and their components are selected primarily to meet the requirements of the Performance Standards (IEC 61215 and IEC 61646) and Safety Standards (IEC 61730 and UL 1703).
- This presentation will explore the issues related to designing and building modules to meet standards rather than to survive in the field.

Why I believe Modules are Designed for Standards

- Too many cases where modules pass one of the tests from the qualification sequence but fail when the test is extended even a small amount.
- One case where new manufacturer's cells in standard package passed 1000 hours of damp heat with little power loss, but just extending to 1250 hours resulted in significant power loss > 20%.
- While at BP Solar we tested 10 crystalline silicon module types from 9 different manufacturers from all over the world, all qualified to IEC 61215.
  - Only 3 passed BP Solar's extended test protocol.
  - Most failed damp heat at 1250 hours.

Extending Test Duration for Cr-Si Modules Qualified to IEC 61215

Manufacturer	DMLC/TC/HF	1250 Hr DH	500 TC
A	Pass	Fail	Fail
B	Pass	Fail	Pass
C	Pass	Fail	Fail
D	Pass	Fail	Pass
E	Pass	Fail	Pass
F	Pass	Pass	Pass
G	Pass	Fail	Pass
H	Pass	Pass	Pass
J	Pass	Fail	Pass
K	Pass	Pass	Pass

What are the ramifications

- Qualification test is not a 25 year lifetime test.
- Qualification test does an excellent job of identifying design, material and process flaws that lead to premature failures (Infant mortality).
- Qualification test does not address wear-out mechanisms that limit lifetime.
- We do not have an accelerated test sequence that can assure 25 year lifetime in all terrestrial environment.
- Relying solely on the Qualification test sequence can mean no assessment or evaluation of how the module will actually perform long term in the field.

Over Design

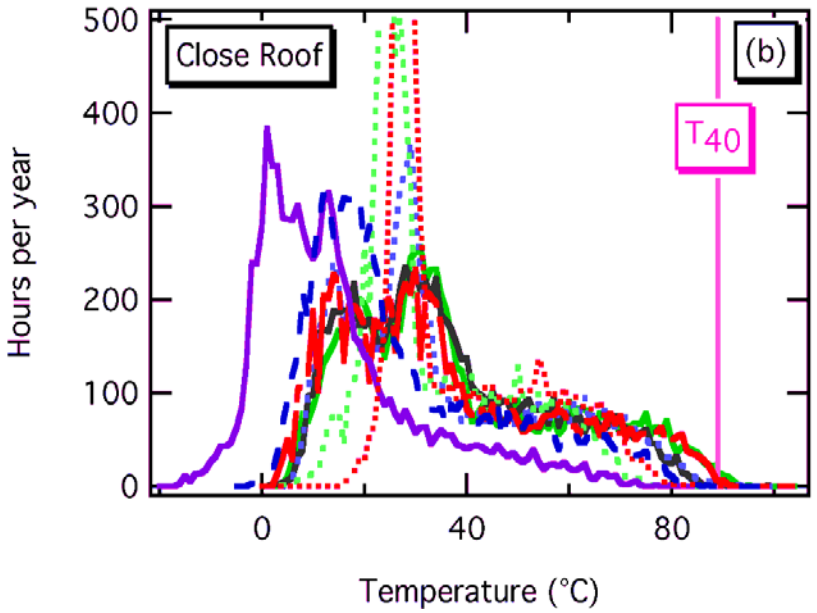
- The safety standards put requirements on the materials within the module.
- These requirements typically come from other fields.
- They may or may not be appropriate for PV applications.
- They often add unnecessary cost to the PV module.
  - Extra testing cost
  - Use of more expensive materials/components just to meet the requirements of the standard not to increase safety.
- Going to discuss 2 examples

RTI

- The UL RTI test has been included in both UL 1703 and IEC 61730.
- Both standards require any polymeric materials within the module to have an RTI rating equal to the temperature measured during the "Temperature Test - T_{40} " plus 20 °C.
- RTI is an exceeding long test (more than 1 year). So slows down and impedes the use of new materials.
- There is little scientific basis for the RTI test. It determines when a property has fallen to 50% of initial value no matter whether that loss of property has anything to do with its performance in the application.

RTI

- RTI usually used where the operating temperature is well known and fairly constant when an appliance is operating. **This is not the case for PV.**
- Modules rarely operate at even the temperature measured in the temperature test.
- Typical Module T_{40} = 90 °C
- See figure for a roof mount module in 6 locations including Saudi Arabia, one of the hottest places in the world.
- A module only spends a few hours a year above the T_{40} temperature and never reaches T_{40} + 20.



"EVALUATION OF HIGH-TEMPERATURE EXPOSURE OF PHOTOVOLTAIC MODULES" By Kurtz etal, TBP in **Progress in PV**

Partial Discharge Test

- IEC 61730 requires the back sheet material to have a partial discharge rating for the highest system voltage the module will be rated for (Typically 600 volts in the US and 1000 volts in Europe).
- The partial discharge test comes from the insulation industry and was typically used to evaluate the insulation on windings in transformers.
- Partial discharge is suppose to help predict wear out of the insulation material after long term exposure to electric fields.
- The test uses
  - 2 conductive planes with the backsheet sandwiched in between.
  - AC to excite the field and cause the discharges

Issues with Partial Discharge Test

- First issue is that there very few cases where the geometry in PV module resembles the test (backsheet sandwiched between 2 conductive planes).

In most cases there are no conductive materials touching the backsheet except maybe at the edges where the internal circuitry (cells and bus bars) must meet the clearance distance for the proposed voltage.

- Second issue is the use of ac rather than the dc that PV modules see.

Very little information is available to indicate that the AC test does anything to predict DC performance.

Why is Partial Discharge Test Important?

- Partial discharge test drives the construction requirements of the backsheet.
- Because of partial discharge test backsheets are much thicker (and therefore more expensive) than would be required to meet all other requirements in IEC 61730 or IEC 61215/61646.
- One module manufacturer estimated that this requirement adds $5 to $6 to the cost of every ~200 watt module.

Termination Requirements

- **Both UL 1703 and IEC 61730 have a similar requirement for module termination.**

"Strain relief shall be provided so that stress on a lead intended for field connection, or otherwise likely to be handled in the field, including a flexible cord, is not transmitted to the connection inside the module or panel." from UL1703

- **Good idea but implemented incorrectly.**
- **NRTL's have allowed this criteria to be met using a potting compound (such as silicone or epoxy).**
- **If the solder bond on the lead fails the pottant holds the lead in place allowing an arc to develop and possibly continue for an extended time period.**
- **This has been one of biggest PV safety issues.**

Solutions

- **For Design to Qualification Test:**

Develop a set of accelerated stress tests that predict module performance over 25 years in various terrestrial climates.

QA workshop In Tokyo in May, 2011

- **For RTI**

Replace RTI with requirements for materials that are developed specifically for the environments in which PV modules operate.

Underway in WG2 - Participate in this effort

- **For Partial Discharge**

Only require partial discharge test when module is designed to have conductive material in contact with the back of the backsheet. (Part of mounting system or metal foil for humdiity barrier)

Support this change in your national committee when voting on IEC 61730 edition 2

Solutions (Continued)

- **Termination Issue**

Latest draft of 61730 edition 2 changes wording on termination to require redundant electrical connections.

Support this change in your national committee when voting on IEC 61730 edition 2.

- **Redundancy Issue**

Replace UL 1703 with IEC 61730 so US industry isn't hampered by having to carry double safety certifications nor have to correct the problems in 2 standards.

Let UL, Solar ABCs and DOE know that this is a priority for US PV industry.