NREL
NATIONAL RENEWABLE ENERGY LABORATORY

International Quality Assurance Standards

PV Module Reliability Workshop

Golden, CO

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This presentation has no confidential information

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Background

Many are asking for tests to make more quantitative predictions about PV modules:

- Companies: want to test to validate warranty
- Customers: easily compare quality of products
- Investors: establish acceptable risk
- Insurance companies: calculate risk

Many groups have begun developing tests that "go beyond IEC 61215"

Quality Assurance
(two parts)

1. Quality of design to withstand stresses in local environment (defined by climate and application)
2. Consistent quality from manufacturing line

We propose:

To work together internationally to create quality assurance standards – we will discuss this at a workshop in Japan in May, 2011

Benefits of Semi-quantitative QA Standards

- Customers can more easily assess quality/durability of products and choose the product that best meets their needs
- PV companies can better align product design with desired applications, potentially enabling lower costs
- Established companies can differentiate their (more durable) products
- New companies can better demonstrate durability of their new products
- Investors can better assess risk for investments anywhere in the world
- Insurance companies can begin to relate field performance to QA history

Example of Possible Rating System – Presented to Stimulate Discussion

Stress	Rating system	Accelerated test	Environmental definition
Voltage	Numeric value for maximum system voltage	As per IEC 61215, or revised to be applied during damp heat	System voltage
Temperature	Classes Hottest, Hot, Warm, Cool	Damp heat, possibly with voltage bias applied	Estimate assuming Arrhenius type behavior and create maps for rack and roof mounting
Thermal cycling	Class A, B	Thermal cycling as per IEC 61215, but two levels of 400 or 1000 cycles	Make map; partly cloudy locations have fastest degradation
Humidity	Class Humid, Dry	Damp heat, possibly with voltage applied	Average humidity; make map
Snow	Numeric rating for kg of static load	IEC 61215 static load test	Snow load from local building code
Marine environment	Numeric severity rating	Existing IEC test	Distance from ocean
Hail	Numeric rating for size of hail ball	Current default is 25 mm; method is already defined in 61215	Generally, people know the size of hail to plan for, but maps are not easily available
UV	Class A, B	Class A designed for high-altitude site	
Wind	Numeric rating for maximum wind gust	Combination of dynamic load test, vibration, and?	Maximum wind speed seen during gusts; available through weather data
Transportation	Rough/Smooth	Vibration	Type of transport: truck on paved and unpaved roads, train, etc.
Farmland	Pass/Fail	Use ammonia test being drafted by WG2	Agricultural area

Steps to Creating Quantitative Test

1. Define most important failure mechanisms to quantify
2. Collect suggestions for useful tests from engineers around the world (leveraging years of testing experience)
3. Select tests that have the potential to be useful (cost effective way to obtain valuable information)
4. Apply new tests to modules with known field experience
5. Create new IEC standard to define semi-quantitative tests that were useful
6. Through modeling, provide community with maps to show how the test results relate to field performance in different climates/applications

Failure Mechanisms
Which are most important to quantify?

Type of failure/degradation	Related stresses
Broken interconnects, solder bond failures	Thermal cycling, mechanical
Broken cells	Thermal cycling, vibration, mechanical
Corrosion, including electrochemical corrosion; corrosion leading to loss of grounding	Humidity, heat, bias V, dry/wet high pot
Delamination and/or loss of elastomeric properties of encapsulant	Humidity, heat, humidity-freeze, UV, dry/wet high pot
Encapsulant discoloration	UV, heat
Broken glass; structural failures	Mechanical
Hot spots	Hot spot
Junction box and module connection failures	Thermal cycling, humidity, heat, humidity-freeze
Bypass diode failure	Heat (applied to diodes)
Open circuiting leading to arcing	Thermal cycling
Ground fault from backsheet degradation	UV
Ground faults	Dry/wet high pot

Many of the tests are easy to make quantitative

- Thermal cycling test can easily be extended to more cycles
- Mechanical load is already defined to allow testing for different loads and some companies already use glass of different strength for high snow-load applications
- Hail test already allows testing for different size hail balls
- Salt spray test is already defined for multiple environments

QA of Manufacturing Process

- Currently each company has its own QA program (some are better than others)
- Currently there is no consensus guideline for factory inspection or periodic retest
- If a company gets a 61215 certification from a test lab that does not do factory inspections, the certificate may remain valid indefinitely even if the company maintains no QA program – how does a customer know?
- Is IECEE the right organization to implement the needed guidelines, using standards defined by other standards organizations?

Primary Challenge

Combined effects of temperature, humidity, voltage bias and light are very difficult to quantify

- These stresses appear in the environment in highly varying ways
- Simultaneous application of these stresses is expensive
- How can we define a “damp heat test with bias voltage” that can be quantitatively correlated with field performance?

Possible approaches

- UV may be applied to mini module with similar structure
- Voltage bias may be applied during damp heat
- To define four levels of thermal endurance, we could use two different temperatures and two different times

History of Si module qual. test: JPL (Jet Propulsion Lab) Block buys

Test	I	II	III	IV	V
Year	1975	1976	1977	1978	1981
Thermal Cycle (° C)	100 cycles -40 to +90	50 cycles -40 to +90	50 cycles -40 to +90	50 cycles -40 to +90	200 cycles -40 to +90
Humidity	70 C, 90%RH, 68 hr	5 cycles 40 C, 90%RH to 23 C	5 cycles 40 C, 90%RH to 23 C	5 cycles 54 C, 90%RH to 23 C	10 cycles 85 C, 85%RH to -40 C
Hot spots	-	-	-	-	3 cells, 100 hrs
Mechanical load	-	100 cycles ± 2400 Pa	100 cycles ± 2400 Pa	10000 cyc. ± 2400 P	10000 cyc. ± 2400 Pa
Hail	-	-	-	9 impacts 3/4" - 45 mph	10 impacts 1" - 52 mph
NOCT	-	-	-	Yes	Yes
High pot	-	< 15 μA 1500 V	< 50 μA 1500 V	< 50 μA 1500 V	< 50 μA 2*Vs+1000

JPL Block buys led to dramatic improvements – can we learn from this?

- One study claimed (Whipple, 1993):
  - Pre-Block V: 45% module failure rate
  - Post-Block V: <0.1% module failure rate

- Primary differences for Block V included:
  - 200 instead of 50 thermal cycles
  - Humidity freeze
  - Hot spot test

- If we pool the community's data, can we identify the most useful tests?

Do you have suggestions?

Write your suggestions here:

Or, contact Sarah.Kurtz@nrel.gov or any of the other authors