GENERAL TEST REQUIREMENTS AND PROCEDURES BASED ON IEC 61215

SCOPE AND OBJECTIVE

Currently in the c-Si PV module industry, there is no established and accepted accelerated test of a module's long term performance and reliability. Many manufacturers have proprietary testing regimens, and are using their in-house testing to ensure that their products will hold up well over time (25+ years) as well as to passively test their competitors’ modules for inter nal benchmarking.

Purchasers of tens of MW of modules spending considerable time working with banking institutions to assess project financing are experiencing increasing module quality questions/hurdles/barrriers during project financing diligence, as investors/lenders reevaluate long term investment risk due to module quality and performance assumptions.

Though PV module manufacturers strive to ship products that will survive or outlast their stated warranties, very little attention has been given to degradation pattern of those modules while in the field. Simple assumptions of a uniform and linear 0.5 - 0.7% degradation rate in module performance per year are being questioned carefully, especially when array sizes are increasing greatly and the impacts of non-uniform degradation on array performance are considered.

Many module manufacturers spend a considerable amount of time and money on quality and are not able to monetize that quality perceived the "commoditization" of the PV module market. Project developers/investor-operators are concerned about the degradability of their energy yield models in years 10-25 (the years beyond the IEC 61215 testing schema). Although they want to buy quality, they have had no independent way to verify the proper test results shared with them under NDA.

Thus, a critical mass of manufacturers got together and jointly developed an agreed upon long term reliability and degradation testing protocol that can then be implemented by an independent testing authority/laboratory, called "The Thresher Test for c-Si PV", with the intention of bringing long-term performance test data to the market.

This proposed "Thresher Test" will develop a new long-term reliability test program that will not only help in determining the performance of a product, but also in determining the degradation patterns of different c-Si solar modules.

This Thresher Test does not apply to modules used with concentrated sunlight.

CONTRIBUTORS & PARTICIPANTS

Sincere thanks and acknowledgement are given to the following individuals who have participated in various ways to the development of the “c-Si Thresher Test”:

Hugh Kuhn, Solar Power Partners, - Program Leader
Alelie Funnell, RETC - Project Coordinator
Giovandrea Tschmi-McHarg, ASU/TU Delft Rheinland
Daniel Cunningham, IFP SOLAR
Matthew Blizek, United Photovoltaics Solutions
Surki Panda, DuPont Photovoltaics Solutions
Keith Shellard, KYOCERA
Glenn Tomayasan, MITSUBISHI
Peter Hracke, NREL
Sarah Kurtz, NREL
Jenni Meyersbray, PVEL
Cheryl Kedc, RETC
David King, SAND Labs
Alex Marker, SCHOTT
Paul Burkham, Sharp
Michael Laskey, Sharp
Bill Niedbalko, SOLON
Neil Shey, SOLON
Ian Cambre, SOLON
Oliver Koehler, SUNPOWER
Hinrich Koch, SURFовых
Wei-Te Kwek, SUNTECH
Jan Haisme, TRINA Solar
Anthony Chia, TRINA Solar
Guyon Arkin, TUV SUD
Robert Puts, TUV SUD
Kenneth Saur, TINGS SOLAR

SAMPLING

Eight modules (plus spares as needed) shall be taken at random by a Third Party from a production batch or batches, in accordance with the procedure given in IEC 60410.

The modules must have been fabricated based on manufacturer's BOM and in accordance with the relevant drawings, process specifications / inspections and quality control.

The modules shall be submitted together with manufacturer's Safety Installation, Manual, Manual handling, mounting and connection instructions including maximum permissible system voltage, power rating, application class.

MARKING

All eight modules shall carry the following clear and indelible marking:

- Manufacturer's name or Symbol
- Model Number
- Serial number
- Power Rating
- Maximum DC voltage for which the module is suitable
- Traceability: date and place of manufacture

DAMP HEAT w/ SYSTEM VOLTAGE BIAS

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long term degradation by system bias voltage is not covered in IEC 61215</td>
<td>This test is designed to determine the failure rate of a module under prolonged exposure to damp heat and system bias voltage conditions. Studies in the industry have shown that at least 20% of all c-Si PV modules experience system bias degradation. In such environments, damp heat with system bias voltage can induce even greater current leakage through the module. This test simulates these conditions by heating the module to 150°C, as metso-chemical corrosion. Some stripe tests known are applied at the dielectric strength, mechanical stress, and the module's ability to withstand the 10% DSR solar simulator output. The test is also intended to simulate operating conditions of the module in the field, and from the atmosphere. (Reference Peter Hracke, NREL, &quot;System Bias Voltage Stress Effects in Multicrystalline Silicon Modules&quot;);</td>
</tr>
</tbody>
</table>

System Voltage Bias | Module: | Damp heat test with voltage bias (as per manufacturer's grounding instructions) |
| --- | --- | --- |

DATA AND RESULTS

The "Thresher Test" goal is not a Pass / Fail test but rather a test designed to gather and report degradation through all phases of the test sequences described in Table 1- and Test Flowchart.

The Test cycles / hours are as follows:
- Temperature Cycle = 600 cycles at 100 cycles interim test points
- - Damp Heat with and without System Voltage Bias = 2000 h at 4000, 8000, 12000, 16000, 20000 interim test points
- Damp heat test duration for all tests = 2000 h
- Humidity in 30 cycles at 10, 20, 25, 30 cycles

Testing shall be terminated when one of the following is encountered or achieved:
- A. The power output power output degradation reaches >20% from initial power rating test data
- The maximum test sequence test cycles / hours are completed

The "Thresher Test" data and results will be reported by the Third Party Testing Laboratory to the Manufacturer who may decide to publish it, as they see fit.

The Manufacturer can only publish their own data.

The data and results will ultimately be used by Buyers / Developers to enable them to set their own threshold and suit their own requirements.

REFERENCES

IEC 61215-2005, Crystalline silicon terrestrial photovoltaic (PV) modules - Environmental testing - Part 1: General and guidance
Peter Hracke, NREL, "System Bias Voltage Stress Effects in Multicrystalline Silicon Modules"
IEC 60008-2-11:1999, Environmental testing
IEC 6068-2-78:2001, Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state
IEC 60410:1973, Sampling plans and procedures for inspection by attributes
IEC 60703-2-1:1997, Classification of environmental conditions - Part 2: Environmental conditions appearing in nature - Temperature and humidity
IEC 60981:1987, Procedures for temperature and irradiance conditions to measure the spectral characteristics of crystalline silicon photovoltaic device. Amendment 1 (E092)
IEC 60904-1:19987, PV Devices - Part 1: Measurements of PV current voltage characteristics
IEC 60904-7:1998, Photovoltaic devices - Part 7: Constructional and intrinsic mismatch error introduced in the testing of a photovoltaic device
IEC 61853: Performance testing and energy rating of terrestrial photovoltaic (PV) modules 1
ISO 9001:2008, Quality management requirements for competence of testing and calibration laboratories.

CONTACT INFORMATION

For further questions, please contact:
Hugh Kuhn
khk@sunpowerpartners.com
Alelie Funnell
alelie@retc-ca.com