Evaluation of Mechanical Stress Beyond IEC 61215

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Introduction & Motivations

- A robust and comprehensive mechanical load test protocol for evaluating new frame design and alternative mounting methods is critical to ascertaining the impact to long-term product performance and reliability.
- Developed at Yingli’s state-of-the-art Photovoltaic Testing Laboratory, the Yingli Mechanical Loading Sequence is a mechanical evaluation procedure focused on systematically quantifying the performance implications from stress induced defects, such as micro-cracks, through sequential mechanical, thermal, and humidity stresses.
- Module characterization is expanded both quantitatively and qualitatively with multi-irradiance power measurement and electro luminescence (EL) imaging throughout the test process.

Existing Standard Review

<table>
<thead>
<tr>
<th>IEC 61215 10.16</th>
<th>Yingli Mechanical Loading Sequence</th>
<th>Benefits of VSM NES</th>
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</thead>
<tbody>
<tr>
<td>Static Mechanical Loading</td>
<td>Multi-Irradiance Testing (500 Pa)</td>
<td>Enables quantification of how the stress affects module performance at irradiations other than 1000W/m²</td>
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<tr>
<td>No EL imaging</td>
<td>Multi-Irradiance Methods</td>
<td>Enables multi-irradiance stress testing, understanding of risk associated with different mounting methods &amp; provides end users with more flexibility with system design</td>
</tr>
<tr>
<td>Static Mechanical Loading</td>
<td>Thermal Cycling and Humidity Stresses</td>
<td>Ensures both the interconnect ribbons and mechanically separates the micro-cracks</td>
</tr>
<tr>
<td>No Best Mechanical Loading Atmosphere</td>
<td>Chamber Stress</td>
<td>Ensures both the interconnect ribbons and mechanically separates the micro-cracks</td>
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Dynamic Mechanical Load Protocol Development

- A 3x3 factorial experiment was performed on modules for dynamic mechanical stress after static mechanical stress based off existing literature review and communication with industry experts.

Yingli Solar Mechanical Load Testing Sequence

Test Process Flow

1. Initial Characterization
2. After Static Mechanical Stress
3. After TC50
4. After Dynamic Mechanical Stress
5. After HF10
6. Post Static Mechanical Loading
7. Post TC50
8. Post Dynamic Mechanical Loading
9. Post HF10
10. EL Imaging (Isc & 1/10th Isc) & EL characterization every 1,000 Cycles

Example of Test Results

Comparison of Mounting Methods

Inside Mounting Method: Progression of Micro-cracks

Inside Mounting Method: In Detail

3. Wohlgemuth, J. “Dynamic Mechanical Load Test Protocols” Email to the author. 30 July 2012. E-mail