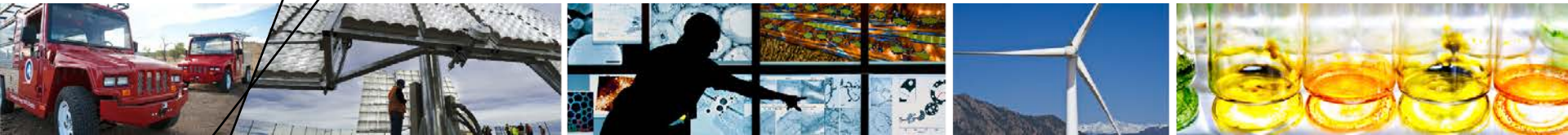


# Qualification Plus

## Performance and Durability Tests Beyond IEC 61215



### 2014 PV Module Reliability Workshop

**Sarah Kurtz, NREL**

**Michael Kempe, NREL**

**Nick Bosco, NREL**

**Peter Hacke, NREL**

**Thomas Earnest, DuPont**

**Dirk Jordan, NREL**

**David Miller, NREL**

**Timothy Silverman, NREL**

**Nancy Phillips, 3M**

**Ralph Romero, Black & Veatch**



# California Energy Commission

---

- **Updating PV equipment requirements (2014)**
- **UL 1703 and IEC 61215 mandatory**
- **“Qualification Plus”**
  - Voluntary, non-proprietary
  - Improved quality, reliability, durability
  - Protection for consumer, ratepayer, taxpayer, investor



# Module Durability

---

- **IEC 61215 does not test for long term survival.**
- **Manufacturing audits are inconsistent.**
- **Warranties are often of little use.**
- **Modules can fail before 25 years.**
  - Manufacturing defects.
  - Design defects.
  - Safety defects.

# Determining what to include

---

- **Related to observed field failures**
- **On path to international standards.**
- **Random sampling: No cherry picking.**
- **Ongoing Testing: Not one time event.**
- **Production modules same as tested modules.**

# Qualification Plus Tests

---

- **Components**

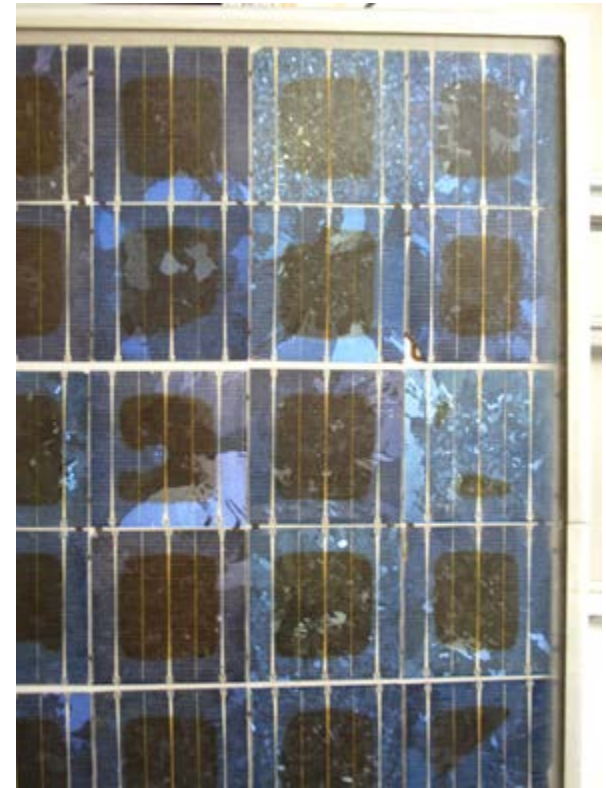
- **UV Tests for Encapsulants, Backsheets, Cables, Connectors and Junction Boxes**
- **Longer Duration Bypass Diode and Junction Box Thermal Test**

- **Modules**

- **500 Thermal Cycles**
- **Dynamic Mechanical Load**
- **Potential Induced Degradation (PID)**
- **ASTM Hot Spot Test**

# Encapsulation Discoloration

- **Discoloration caused by UV = Power Loss**
- **Increase UV test 15X**
- **Accelerate with Temperature**



# Long Term UV Degradation of Polymeric Components

- Backsheets can degrade from front side
- Polymer degradation = potential power loss or safety hazard
- **Increase front UV test 20X**



Degraded Backsheet from Gambogi SPI 2013

# Long Term UV Degradation of Polymeric Components

- Back of module can see 10-15% reflected UV.
- Polymer degradation = potential safety hazard
- **Add UV exposure tests**
  - Backsheet
  - Junction Box
  - Cables
  - Connectors

Degraded Wires



Degraded Backsheet from Gambogi SPI 2013



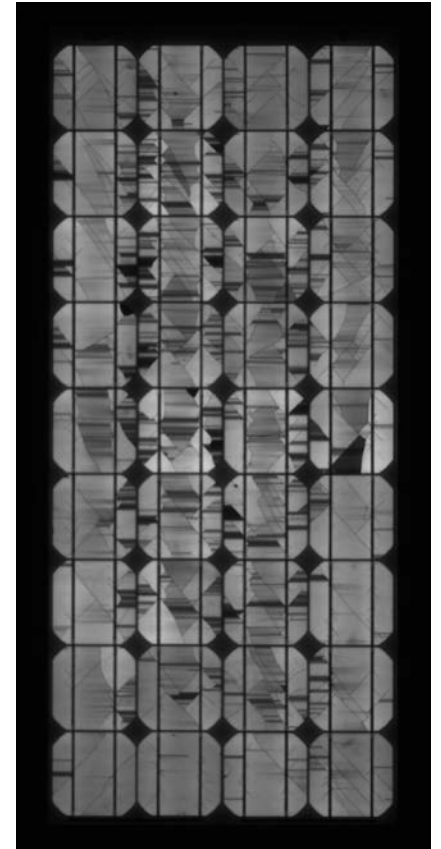
# Bypass Diode Failures

- Bypass diode failures in field can lead to module damage.
- Increase test time from 2 hours to 96 hours.



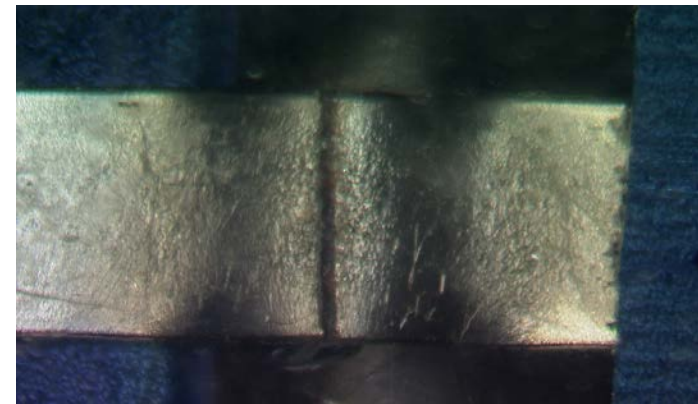
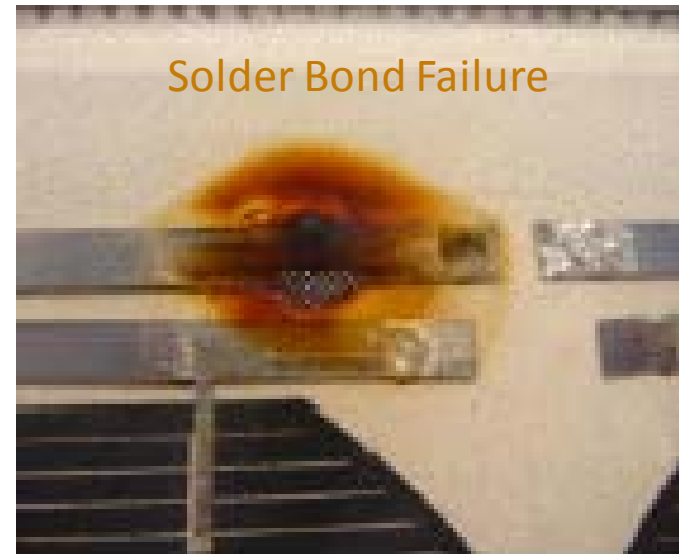
# Cracking of Crystalline Si Cells

- Cells getting thinner
- Can break due to fabrication, transportation, handling, installation and wind loading.
- **Add dynamic mechanical test**



# Cell interconnect ribbons and solder bonds

- Modules surviving 200 thermal cycles can fail in field.
- Increase 2.5X to 500 cycles.

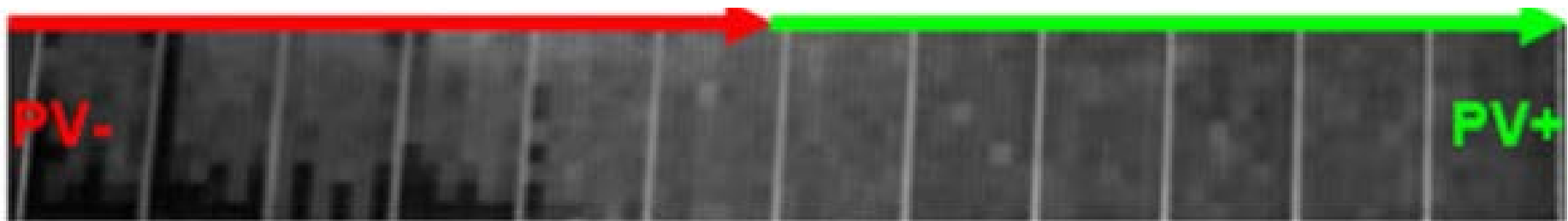


Broken  
Interconnect

Kato, 2012  
PVMRW

# Potential Induced Degradation

- Power loss in high voltage & high humidity
- Add test combining humidity, temperature & voltage.



Electroluminescence of mc-Si module strings indicating shunting in the negative portion of a center mounted or floating string

S. Pingel et al., "Potential Induced Degradation of Solar Cells and Panels," 35th IEEE PVSC, Honolulu, 2010, pp. 2817–2822.

# Qualification Plus Sampling Requirements

---

- **5 random modules from production line.**
- **If any module fails, the overall test is failed.**
- **Tests repeated at least annually.**
- **Certification by ILAC or IECCE laboratory.**

# Quality Management System

---

- **Meet “Guide for Quality Management System for PV Module Manufacturing: Supplemental Requirements to ISO 9001-2008”**
- **ANAB or IAF approved Certification Body**

# Summary: Qualification Plus

---

- **Accelerated stress tests beyond IEC 61215.**
- **Based on observed field failures.**
- **Future IEC standards.**
- **Production products – Not Prototypes.**
- **Continuous processes.**
- **Defined Quality Management System.**