Field Observations and Product Returns – What can we learn?

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INTRODUCTION

- **PV modules are designed to work outdoors, therefore observations of the performance of fielded modules are important.**
- **But why should we be interested in determining how and why fielded modules fail?**
- **How can we use field and return data to improve our products?**
- **How can we use field and return data to develop better accelerated tests?**

Field Observations

- **Active – Install product in various climates and observe performance.**
- **Semi-active – Monitor fielded systems to determine energy production and any long term decrease in output.**
- **Passive - Analyze product returns**

Product Return?

- **Equate product return with warranty return. Companies promise to replace module under certain conditions.**
- **Not all returns are “failures”.**
- **Some “failures” are of the system not the product – for example;**
  - **the wrong product was shipped or**
  - **Product was damaged during shipment.**

What is a Failure?

- **Customer service definition – Product failed to meet the customer's expectation.**
- **Technology definition –Product failed to meet specification and terms of warranty.**
- **Failure can be in terms of different criteria not being met. For modules these are typically:**
  - **Power/Performance**
  - **Functionality**
  - **Safety**
  - **Workmanship**
  - **Cosmetics**

What is a Failure Analysis?

- **Determination of why a module was returned ("The claim"). – For example low power**
- **Determination of whether it is really a failure. – Does it still meet the specification and/or warranty conditions?**
- **Identification of root cause for failure.**
- **Remember – Decision to accept a warranty claim is a commercial decision.**

Why do failure analysis of fielded modules?

- **To determine if the sky is falling-** That is, are all of the modules you have manufactured and sold likely to fail before the warranty expires.
- To estimate what fraction of fielded modules are likely to suffer the same failure mode. – What warranty reserves ($) do we need?

Why do failure analysis of fielded modules? (cont)

- To determine what product changes are necessary in order to eliminate or reduce the potential for this failure.
- To help establish accelerated tests to screen new products for this failure mechanism.
- To identify and communicate potential safety issues with your product.

Observations and Measurements Tools

- **PV Performance (I-V curve)**
  - **Normal**
  - **With shadowing on selected cell(s)**
- **Dry Hi-Pot**
- **Wet insulation resistance**
- **Visual inspection: Looking for any evidence of**
  - **Discoloration**
  - **Delamination**
  - **Embrittlement**
  - **Corrosion**
  - **Overheating or burning**
- **IR camera – forward and reverse bias to see non-uniform heating**
- **Adhesion of layers, boxes, frames, etc.**
- **Photoluminescence – Junction integrity and cracked cells**
- **Materials Analysis**

Mechanisms for Power Loss

- Broken interconnects
- Bad solder bonds – cells, bus bars or wires
- Cracked cells
- Corroded contacts – cells or wiring
- Corroded thin film layers
- Inadequate isolation scribe lines
- Shorted bypass diodes
- Cell hot spots leading to shunting
- Arcing – ground fault or open circuit due to one of the other causes
- Discoloration of Encapsulant

Mechanisms for Functionality

- **Glass Breaks – Why?**
- **Structural Failure – Frame, mounting structure, adhesives**
- **Junction box/Output Leads no longer attached to module.**

Mechanisms for Workmanship

- **Delamination of Encapsulant**
- **Frames loose**
- **Junction box loose**
- **Any of items from Power or Functionality list before they have reached critical level.**

Mechanisms for Cosmetics

- **Discoloration of encapsulant, frames, cover sheet or back sheet**
- **Foreign items within package**
- **Misalignment – Cells in package, glass in frame, etc.**
- **Variations in thin film coating thickness (Semiconductors within thin film modules, AR coatings on cells or on glass)**

Safety

- **Exposure to High Voltage**
  - Holes in front or back sheet
  - Adhesion of junction box
  - Faulty connectors
- **Potential for Fire**
  - Ground faults
  - Open circuits: DC arcing
  - Cell Hot Spots

Identifying Cause

- Determining root cause (for example low power because of broken cell interconnects) is only the beginning.
- Next question is why did the failure occur?
- Look at samples history.
  - How long in field?
  - Where deployed?
  - What sort of system (anything unusual).
- Is this an isolated occurrence or have we seen this particular failure mechanism before?
- Have you seen this failure as a result of accelerated stress test?

Understanding Cause

- **To truly understand the cause you must be able to duplicate the failure.**
  - **This may be done by selecting the appropriate accelerated test.**
  - **Sometimes it requires longer exposure than normal – for example 500 thermal cycles versus 200 from IEC 61215 or 61646.**
  - **Sometimes it requires combining stresses – for example adding applied voltage during damp heat to accelerate corrosion.**
  - **Sometimes it requires adding new tests – for example adding dynamic mechanical loading before TC/HF to see the effects of cracked cells.**

Using the Understanding

- **Once you can duplicate the failure you can use accelerated testing to determine if the failure was due to:**
  - **A design flaw**
  - **Poor material selection or out of spec material**
  - **Workmanship problems**
  - **Overstressed deployment**

FUTURE

- **Make changes in design, process and/or materials to reduce or eliminate the failure.**
- **Use your new test methodology to assess future changes in product to assure that failure mechanism doesn't reoccur in later generations.**

Acknowledgements

- **Acknowledge work of those at BP Solar doing the failure analysis work.**
  - **Jay Miller**
  - **Danny Cunningham**
  - **Jay Shaner**
  - **George Kelly**