

Humidity, Temperature and Voltage



**2012 PV Module Reliability
Workshop**

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John Wohlgemuth

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Humidity, Temperature and Voltage

Scope:

The ingress of moisture with or without electrical bias has been shown to cause corrosion and charge movement in PV modules. Temperature and humidity have been used as accelerated stress tests for PV modules for many years. However, the use of constant exposure tests, such as the existing Damp Heat Test of 85 C and 85% RH for 1000 hours, appears to result in relative humidity levels far above that which will ever be seen outdoors for breathable package designs and may overstress the module. On the other hand, for semi-hermetic designs, 1000 hours may not be long enough to simulate 20 years of moisture ingress through the moisture barriers. There are multiple humidity and humidity/electrical bias degradation modes with widely varying acceleration factors. The group's development of true accelerated lifetime tests must take variation of environmental conditions into account.

Created 2 groups – Japan and Rest of World

Methodology

How we should develop lifetime tests for humidity

- Determine outdoor failure modes
- Try to duplicate failures using accelerated tests
- Model water ingress in field versus test chamber and then how moisture leads to observed degradation in order to determine acceleration factors

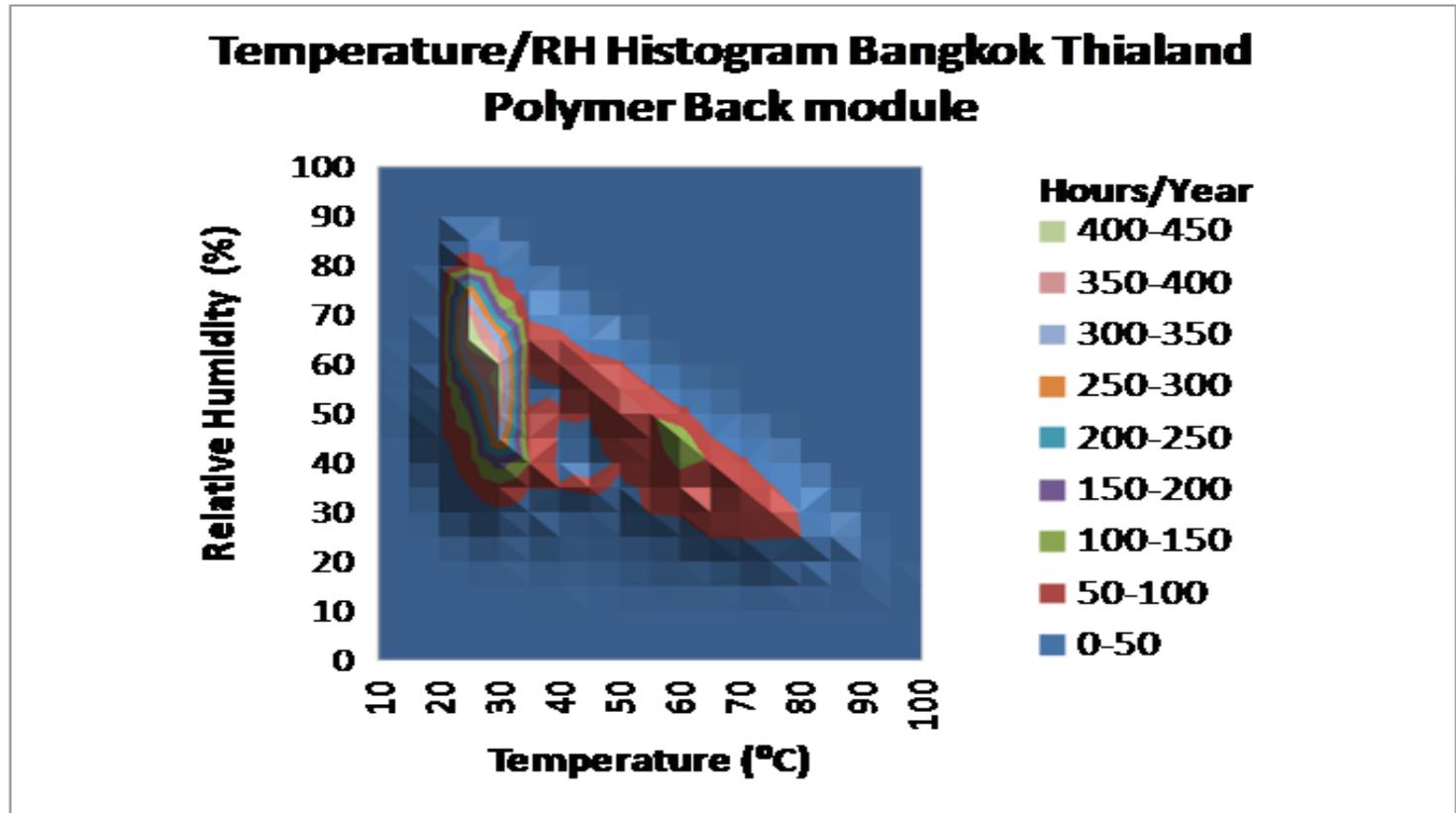
Most proposals for lifetime tests for humidity

- Extend the 85/85 damp heat test
- Determine which modules perform better
- Assume this relationship will hold in field

Problems with this approach

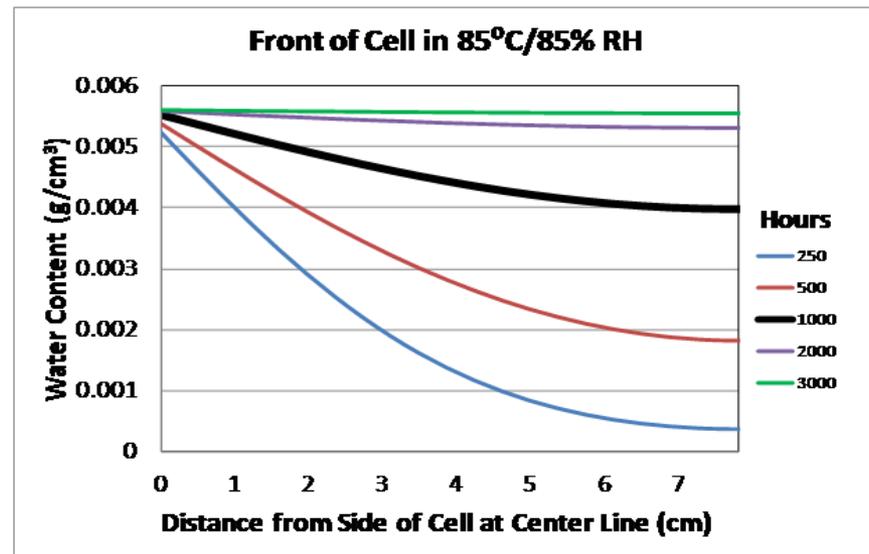
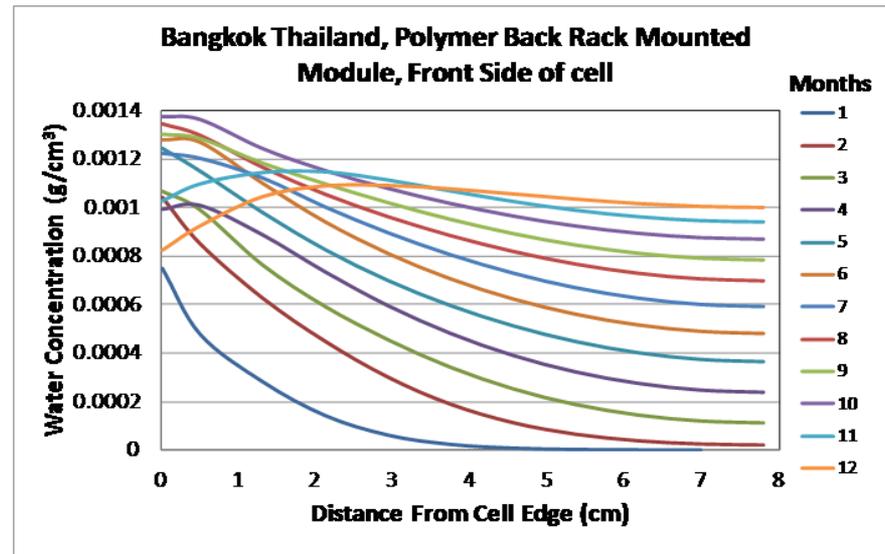
- 85/85 never occurs in real world
- Failure mode occurring after long term 85/85 testing is not observed in field

Modeling of Humidity Ingress into backside of Modules

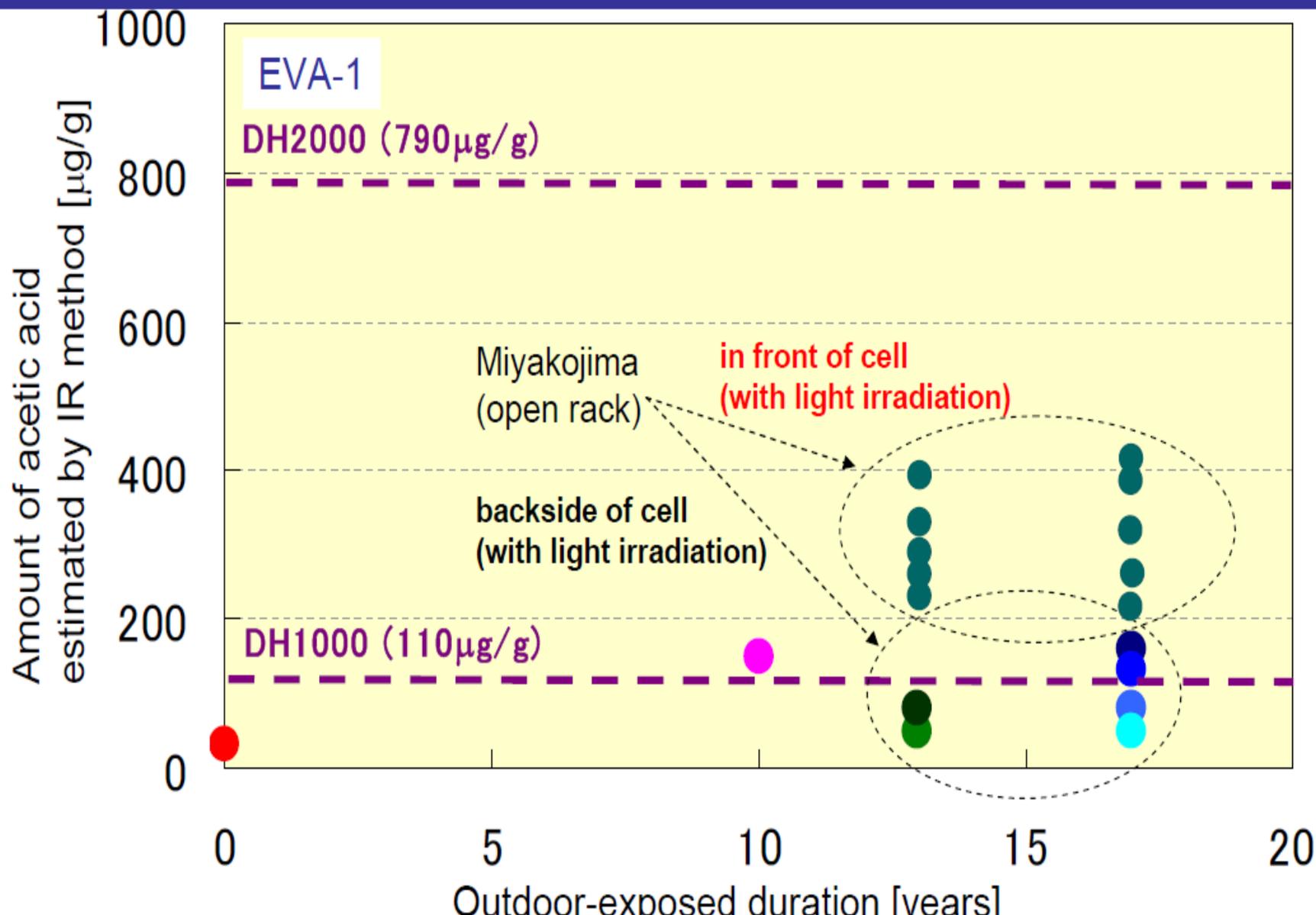


- Modeling of humidity levels in back of PV module with polymeric backsheet in Bangkok, Thailand.
- Damp heat test conditions (85/85) never occurs within module.
- When module has high humidity it cool.
- When module is hot it has low humidity.

Modeling of Humidity Ingress into front side of Modules



Comparison of amount of acetic acid in EVA between long-term outdoor exposure and DH accelerated aging (tentative)



Conclusions/Recommendations

- **Bake-offs (long times at 85/85) do not duplicate field failures.**
- **Need field data, samples & analysis methods**
(probably for all 4 groups)
 - **Lets discuss how we can set up a system to collect this data without identifying specific manufacturers or giving away proprietary information.**
- **Need to determine exactly what mechanism(s) are leading to module degradation in field.**
- **Will have to perform modeling to understand those degradation mechanisms and how they can be accelerated.**
- **Then will have to design new accelerated stress tests that can duplicate the field failures.**