How to Create Certification Programs That Minimize the Risk of Premature PV Module Failures

Weathering Testing as a Tool to Reduce Risk

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View Recorded Presentation

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Q-Lab's New Webinar Series

Today is the second of two new webinars this fall from Q-Lab about specialty weathering testing

All upcoming and archived webinars can be accessed at:
q-lab.com/webinars

Date	Topic
25 Sep	Weathering of wood coatings
02 Oct	Weathering of photovoltaics

Administrative Notes

You'll receive a follow-up email from info@email.q-lab.com with links to a survey, registration for future webinars, and to download the slides

Use the **Q&A feature in Zoom** to ask us questions today!

What is Product Certification?

Product certification or product **qualification** is the process of certifying that a certain product has passed performance tests and quality assurance tests, and meets qualification criteria stipulated in contracts, regulations, or specifications.

--Wikipedia

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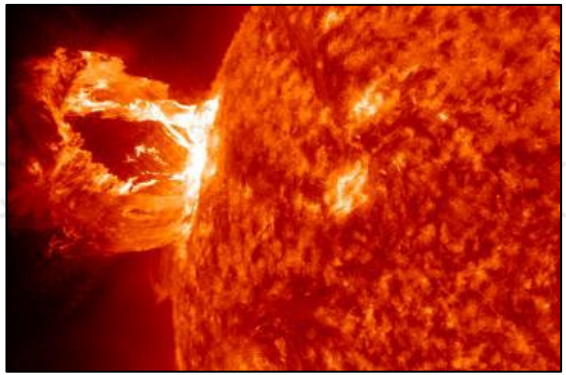
What is Weathering?



Sunlight

Heat

Moisture

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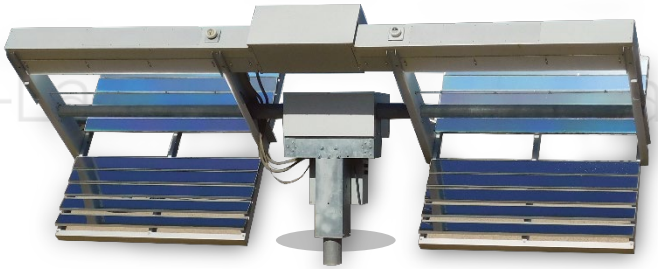
Weathering Technologies

Fluorescent UV

QUV

Xenon Arc

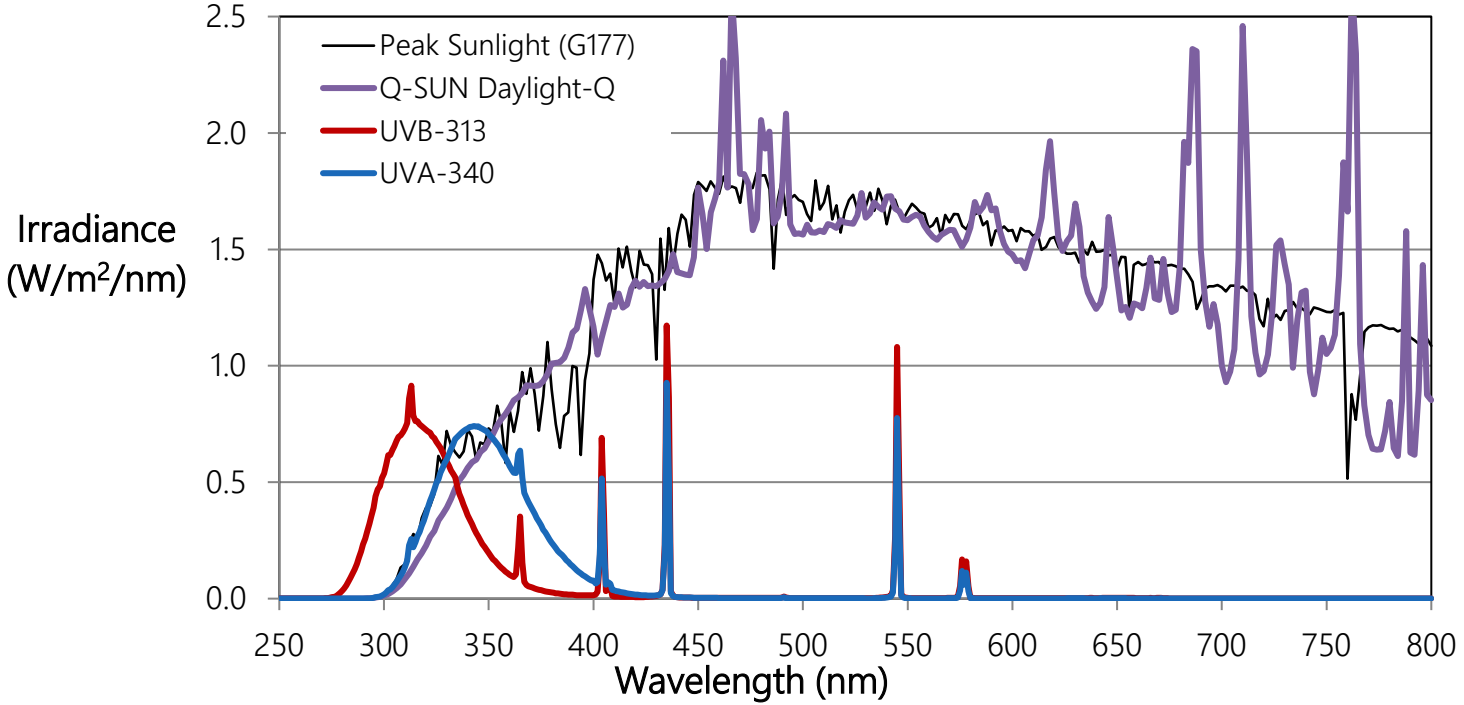
Q-SUN



Solar Concentrators

Q-TRAC

Laboratory Light Sources vs. Sunlight



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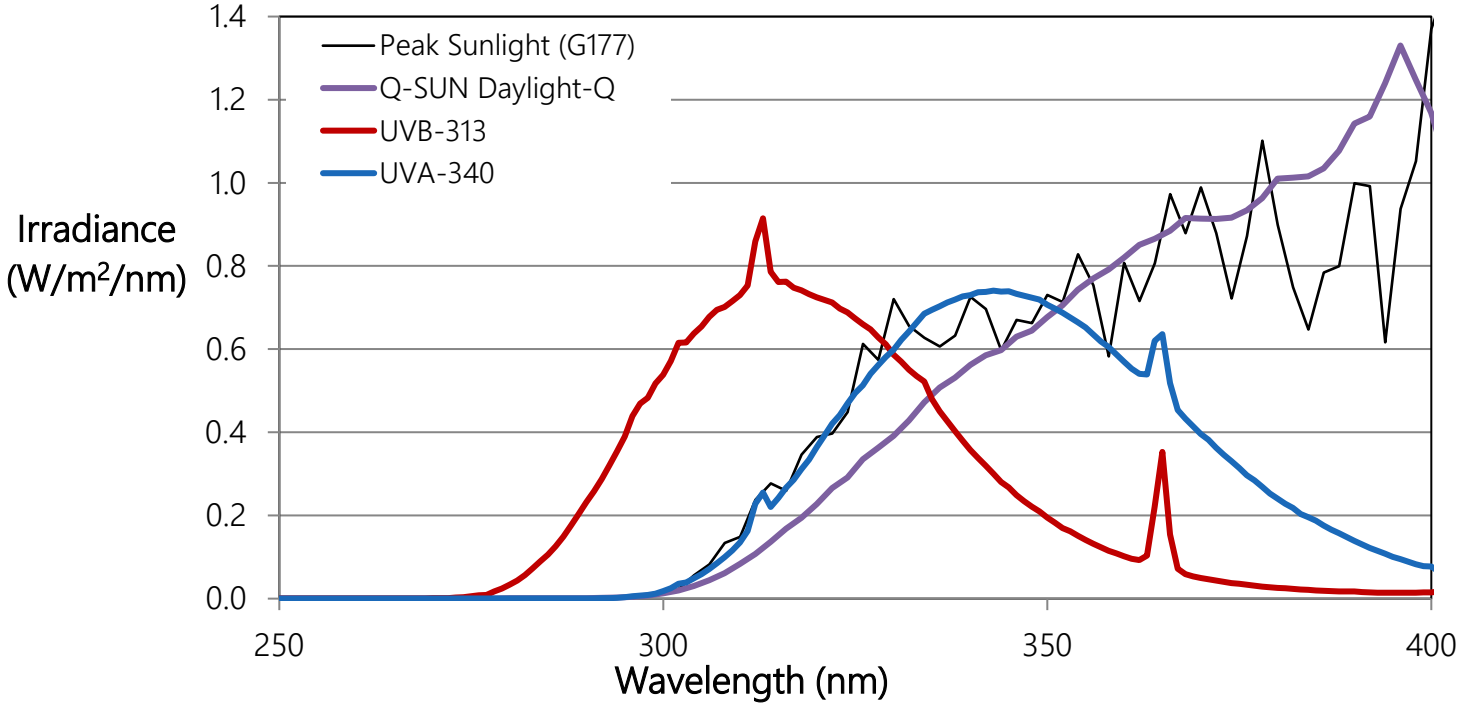
Laboratory Light Sources vs. Sunlight



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What is a Useful Weathering Test?

- A test that helps you make decisions better and/or faster.
- Reduces risk of making bad decisions
- Reduces risk of making decisions too slowly

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Types of Weathering Tests

- Material Screening
  - Rapid pass/fail test to find gross formulation problems
  - Designed to verify quality in production environment
- Material Validation
  - Relatively long pass/fail test required by contract
  - Designed to qualify a material & reduce commercial risk
- Comparative
  - R&D test to evaluate relative performance
  - Works best with test control materials
  - When done correctly minimizes risk of long-term durability claims
- Predictive
  - Develop acceleration factor or mathematical model to predict service life
  - Requires large amounts of data
  - Acceleration factors are unique to a specific material
  - Acceleration factors are usually different for various failure modes

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Difficulties with “Predictive Weathering Tests”

- Degradation is *assumed* to be independent of UV dosage rate (reciprocity)
- Photo-oxidation is often limited by oxygen diffusion
  - Recovers during night (dark) time conditions
  - Limits effectiveness of high-irradiance tests

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Difficulties with “Predictive Weathering Tests”

- Temperature affects photo-oxidation kinetics differently for various materials (activation energy, E_a, varies by material)
- Hydrolysis
  - Can affect and be affected by photo-oxidation
  - Temperature affects kinetics differently by material
- **In other words, weathering is too complex for predictive modeling or universal acceleration equations**

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Now what do we do?

Look to examples of other industries

- Automotive
- Building products (windows, roofing, siding)
- Use weathering tests to reduce risk, not to predict the future

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Now what do we do?

- Material Validation Tests (Laboratory)
  - Xenon Arc
  - Fluorescent UV
- Qualification Test Sequence
- Comparative Tests
- Material Screening Tests for Quality Control
- Real World Tests
  - Standardized outdoor exposures
  - Standardized data collection

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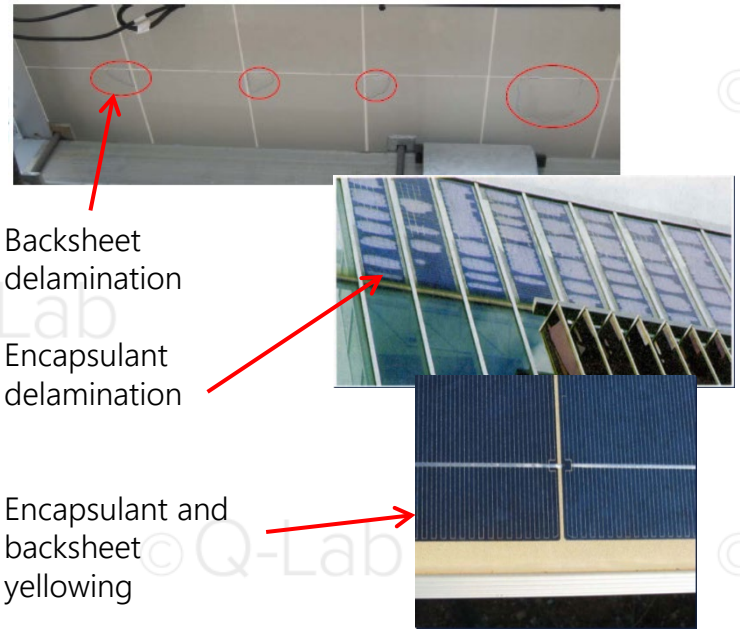
Material Screening & Validation



- Tests of materials or components for suitability in module construction
- Design "Specimen coupon" tests for:
  - Backsheets
    - Sun-facing (though glass) and ground facing (albedo effects)
  - Encapsulants
  - Coupon tests allow use of common weathering methods

Photos courtesy of SunPower
http://www.nrel.gov/ce/ipvmqa_task_force/pdfs/10-ipvmqaf_degraaff_sunpower.pdf

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Material Screening & Validation

Fluorescent UV

- Excellent UV match to sunlight
- Up to 3× AM 1.5 sunlight at normal temperature
- Temperature control
- Condensation & Water Spray

Xenon Arc

- Excellent match to entire sunlight spectrum
- Temperature control (BP & CAT)
- Controlled RH & Water Spray

Module Qualification Tests

IEC (International Electrotechnical Commission)

- IEC 61215
  - Module test sequence
  - Designed to verify initial quality & prevent failures in 1-3 years (early mortality)
  - Tests address specific failure modes commonly seen
- IEC 61730
  - Safety qualification
  - Address safety over 1-3 years (more on that later)
- *Do not address long-term durability*

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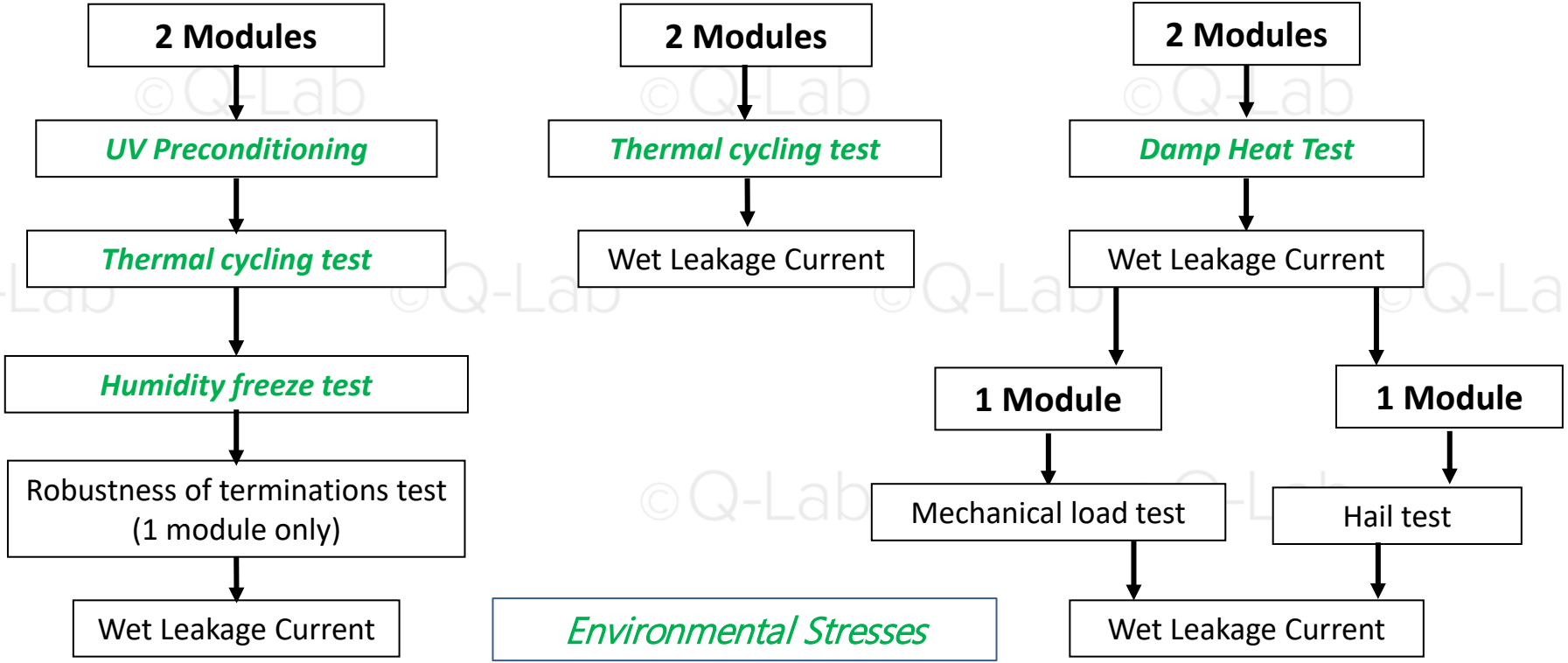
IEC 61215 Test Sequence



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Component Qualification Tests

- IEC 62788 Series
  - Test methods and component material test requirements
  - Tests address specific failure modes commonly seen
  - IEC 62788-7-2, Accelerated weathering tests of polymeric materials
- IEC 61730
  - Safety qualification of modules, but…
  - Require component material qualification according to 62788 series
- *Do not fully address product lifetime durability*

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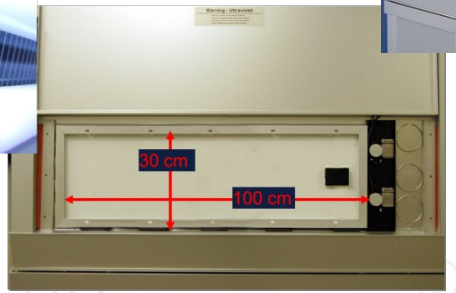
Comparative Tests

- Comparative tests are designed to rank long-term durability of materials or modules but do not provide service life prediction.
- Comparative tests may use specimen coupons or small modules for simultaneous UV, heat, and moisture exposure.
- Full module tests using modified Qualification tests also possible in large chambers.

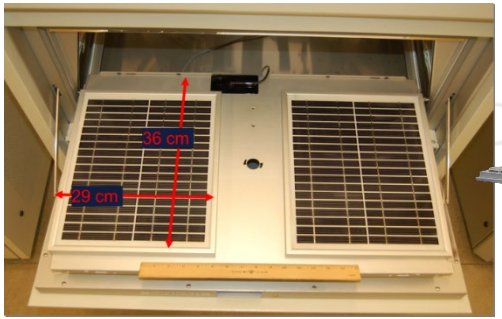
Specimen area of QUV

View from outside

View from inside



Specimen area of Q-SUN



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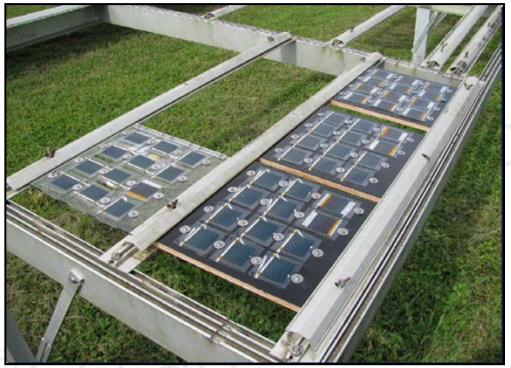
Standardized Outdoor Exposure Tests

- Module mounting and electrical connectivity
- Data collection
- Evaluation tests
- Visual evaluations
- Put modules on test when qualification tests are started
- Over time, correlate outdoor performance with laboratory test results
- More economical when planned up front



Florida

Arizona

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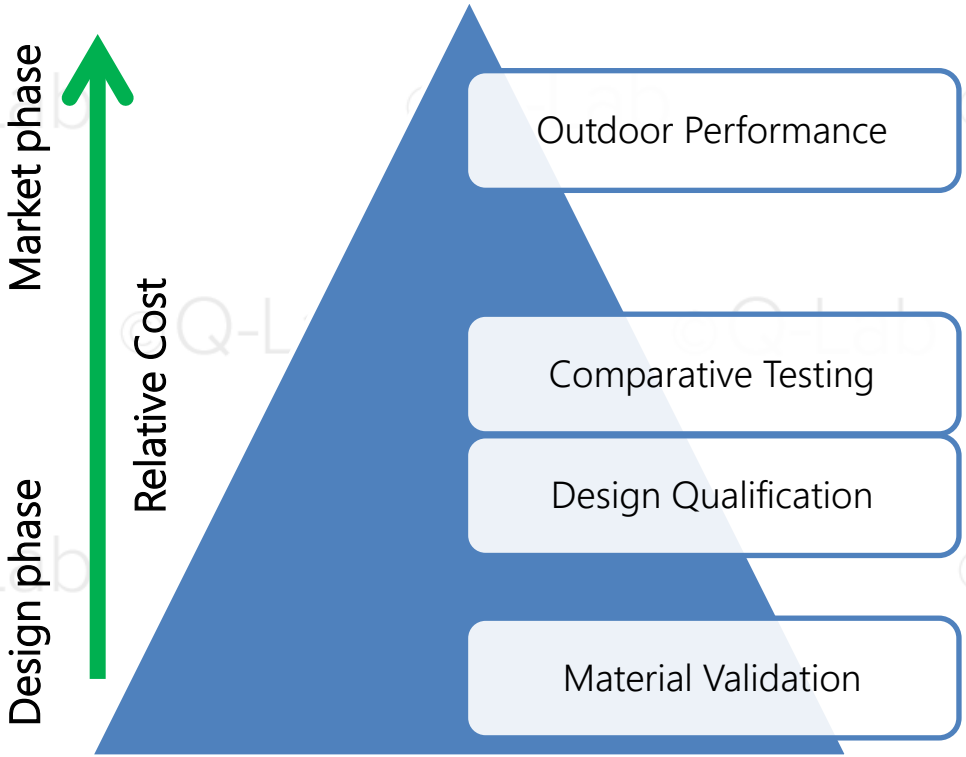
Hierarchy of Durability Testing



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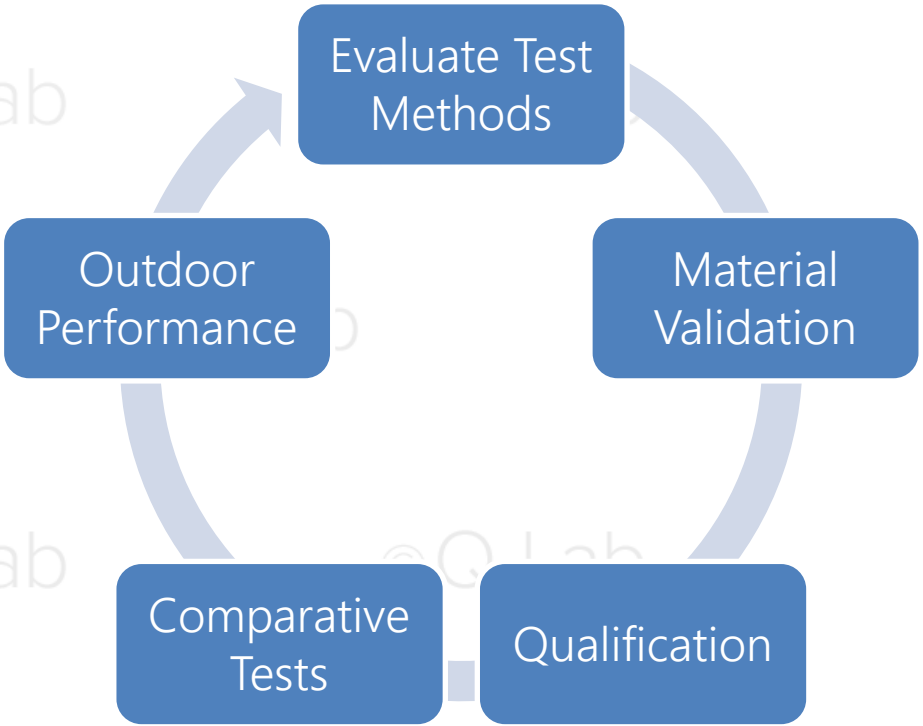
Durability Improvement Cycle



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Manufacturing Quality Control

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How do we accomplish this?

- Standards Community
  - Qualification standards (IEC 61215 & 61730)
  - Material validation (IEC 62788)
  - Quality control (IEC 62941)
  - Extended Stress Testing (National Renewable Energy Laboratory, NREL)
    - Qualification Plus (www.nrel.gov/docs/fy14osti/60950.pdf)
    - IEC TS 63209-1 (modules)
    - IEC TS 63209-2 (polymeric component materials)

- Manufacturers & Suppliers
  - Quality control
    - Material screening prior to production
  - Data collection (outdoor, real world performance)
  - Feed data back into Standards Process (test method improvements, or “sharpening tools”)

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Improving the Methods

- Today, obtaining data on old modules is very difficult
  - Travel to old sites and measure performance
  - This requires a lot of resources for relatively little information
- Tests done according to existing standards rarely correlated to real-world performance
- Data collection in outdoor environment should be standardized and required in certification program
  - Module and material qualification tests compared to real world performance in the future
  - Standards community responsible for using data to improve methods
  - More economical to do this up front

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PV Module Testing Summary

- A variety of tests have been developed to address PV module performance
  - Screening and validation
  - Module qualification
  - Component durability
- Comparative tests along with outdoor testing help establish long-term durability
- 15 years ago, 20-year long-term PV durability seemed like a far-off goal
  - Today, talk is more along 30-40 years
  - PV is one of the fastest-growing energy sectors, and materials and module durability is a major reason why

Thank you for your time.

Questions?

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