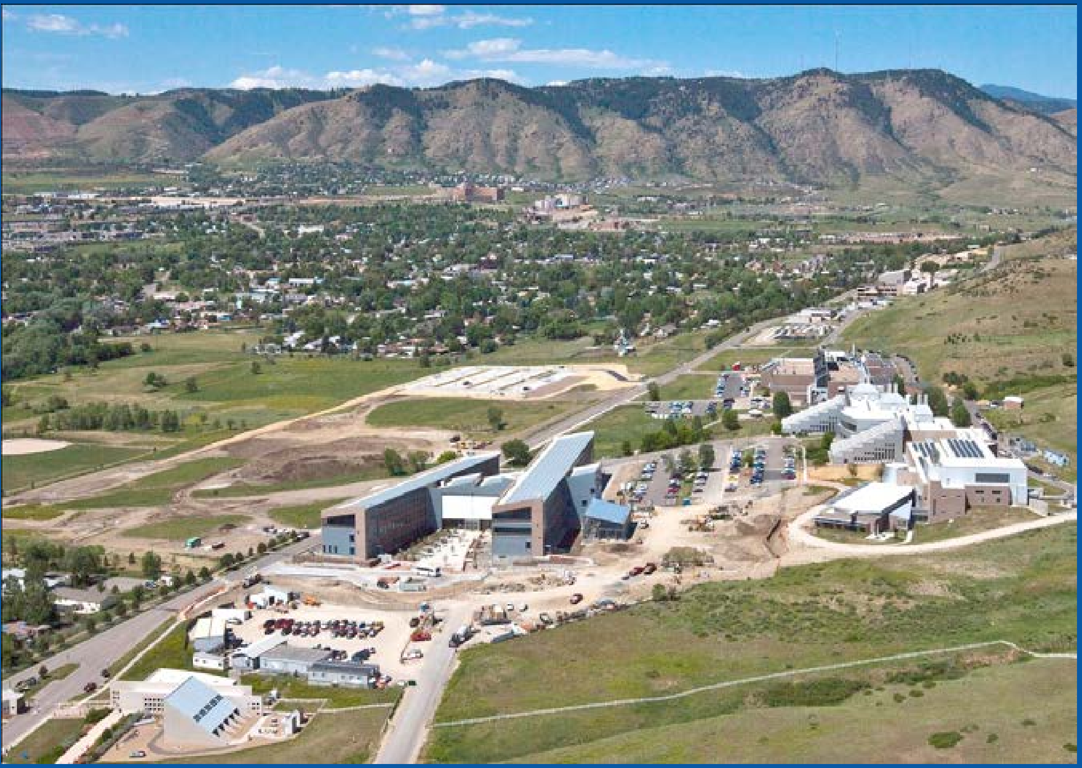
Introduction of Break-out Session



International PV Module Quality Assurance Forum

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We've heard:

- Customers want to be able to assure quality of PV modules (both of design and of manufacturing process)
- Have just heard a proposal about how to structure a PV Manufacturing QA Guideline
- *This Guideline is of highest priority. However, the Forum organizers chose not to hold a break-out session on the Guideline because it is less controversial than testing.*

We’ve heard:

- Customers want to be able to assure quality of PV modules (both of design and of manufacturing process)
- Many new tests have been proposed

- *Next we need to identify what the community feels are important elements for a QA rating system in preparation for forming committees to work on these*

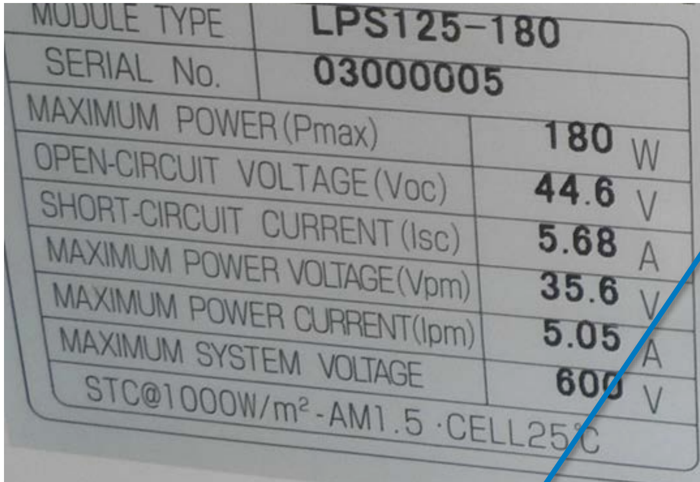
Outline of this presentation

- Review requirements for QA rating system
  - Customer's perspective
  - Manufacturer's perspective
  - Scientific perspective (Stresses and failure mechanisms)
- Logical design of QA system
- Specific tasks for Break out session 1

Requirements for a comparative QA rating system

- Customer's perspective
  - #1 desire: A number that indicates the service life (would this be meaningful?)
  - Relevant to customers' application
  - Easy to understand, but sophisticated customers would like detail
  - Tests that do not add to the cost
- Manufacturer's perspective
  - Single set of tests (applied under ILAC: International Laboratory Accreditation Cooperation)
  - Tests that require minimal time and minimal expense
  - Ability to differentiate products is now attractive
- Scientific perspective
  - Must be meaningful (based on data, not guesses)
  - Logical approach

Logical proposal for QA rating system



1. *Rate according to stresses (put high-level summary of test results on nameplate)*
2. *Test to known failure mechanisms (e.g. thermal fatigue)*

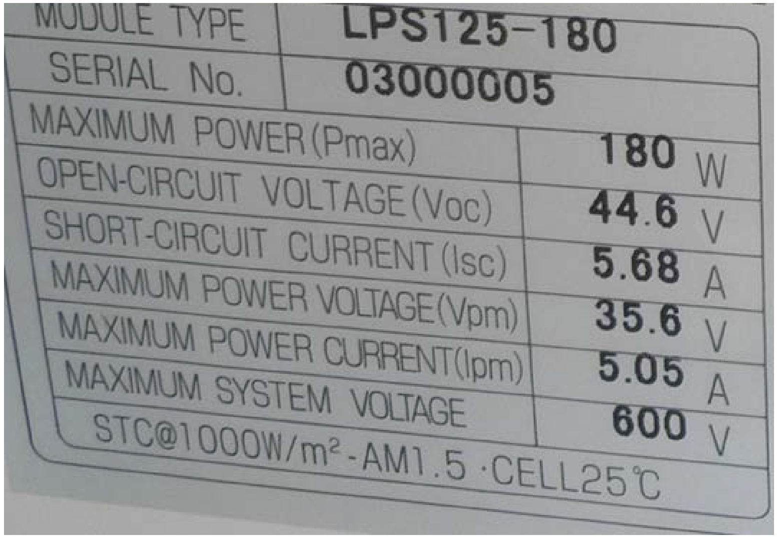
Name Plate

MAX SYSTEM VOLTAGE	600 V
THERMAL ENDURANCE	HIGH
MOISTURE ENDURANCE	LOW
THERMAL CYCLING	LOW
HAIL	28 mm

Thermal cycle test procedure (example, *not proposal*)

	Thermal Endurance LOW	Thermal Endurance HIGH
Thermal Cycling LOW	200 cycles -40 to 85°C	200 cycles -40 to 105°C
Thermal Cycling HIGH	500 cycles -40 to 85°C	500 cycles -40 to 105°C

Logical proposal for QA rating system

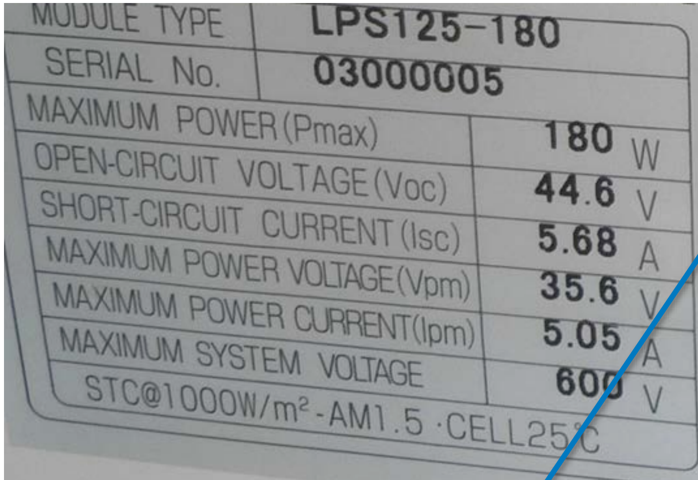


Name Plate

MAX SYSTEM VOLTAGE	600 V
THERMAL ENDURANCE	HIGH
MOISTURE ENDURANCE	LOW
THERMAL CYCLING	LOW
HAIL	28 mm

1. *Rate* according to *stresses*
   - These have meaning to customer
   - Rating should be comparative, not absolute, unless there is a technical basis
2. *Test* and make predictions according to *known failure mechanisms*
   - One test may depend on multiple stresses
   - Failure rate often depends on more than one stress
   - Acceleration factors can be very different for different mechanisms
   - Estimate uncertainties in predictions to guide use of rating

Logical proposal for QA rating system



Name Plate

1. *Rate* according to *stresses*
2. *Test* to *known failure mechanisms*

Thermal cycle test procedure

MAX SYSTEM VOLTAGE	600 V
THERMAL ENDURANCE	HIGH
HAIL	2 CM

Break out session I will create this table

	Thermal Endurance	Thermal Endurance
Cycling HIGH	-40 to 85°C	-40 to 105°C

Break out session II will prioritize failure mechanisms as a basis for forming Task Groups

Stepwise approach – how today's efforts fit in the bigger effort

1. Identify stresses that will be included in rating system (break out #1)
2. Prioritize known failure mechanisms/stress tests (break out #2)
3. Define comparative tests for each stress (Task Groups)
4. Estimate expected lifetimes for prioritized failure mechanisms (Task Groups)
5. Adjust comparative tests to span interesting stress levels (Task Groups)

Break-out sessions

Six rooms: All will have same topic – each person has opportunity to express opinion

Given set of questions to discuss (next slides)

Polls will be taken to judge the consensus of the group

Leaders will summarize and present results

Controversial point:

- Rating *vs* Test Results
  - A rating tells the level at which a test was passed
    - Can be recorded on the nameplate
    - Can be recorded on the datasheet
    - Provides a single number to compare two products
  - Test Results show the evolution of the properties (power output, leakage current, etc.) of a module as the stress is continued
    - Distinguish products that degrade slowly from products that show no degradation, then fail catastrophically
- Proposal: We should do both:
  - The simple rating is useful for the nameplate and easy comparison
  - The full test report is useful to more sophisticated customers and should be available, possibly as a multi-page spec sheet

Note: there is a trade off between more detailed measurements and cost

Stresses and Proposed Rating System

Stress	Rating system	Environmental definition
Voltage	Numeric value for maximum system voltage	System voltage
Temperature	Class Hottest, Hot, Warm, Cool	Use Arrhenius behavior and create maps for rack and roof mounting
Thermal cycling	Class A, B	Thermal cycling comes from changes in irradiance and weather
Humidity	Class Humid, Dry	Average humidity; make map
Snow	Numeric rating for kg of static load	Snow load from local building code
Salt spray	Numeric severity rating	Distance from ocean
Hail	Numeric rating for size of hail ball	Size of hail balls experienced locally
UV	Class A, B	Class A indicates high-altitude or high-irradiance site
Wind	Numeric rating for maximum wind gust	Maximum wind speed seen during gusts
Transportation	Rough/Smooth	Paved/unpaved roads, train, etc.
Farmland	Pass/Fail	Ammonia in agricultural area

Instruction #1 – Are these the right stresses?

Stress	Rating system	Environmental definition
Voltage	Numeric value for maximum system voltage	System voltage
Temperature	Class Hottest, Hot, Warm, Cool	Use Arrhenius behavior and create maps for rack and roof mounting
Thermal cycling	Class A, B	Thermal cycling comes from changes in irradiance and weather
Humidity	Class Humid, Dry	Average humidity; make map
Snow	Numeric rating for kg of static load	Snow load from local building code
Salt spray	Numeric severity rating	Distance from ocean
Hail	Numeric rating for size of hail ball	Size of hail balls experienced locally
UV	Class A, B	Class A indicates high-altitude or high-irradiance site
Wind	Numeric rating for maximum wind gust	Maximum wind speed seen during gusts
Transportation	Rough/Smooth	Paved/unpaved roads, train, etc.
Farmland	Pass/Fail	Ammonia in agricultural area

Instruction #2 – Do we want both a rating system and a test report?

Stress	Rating system	Environmental definition
Voltage	Numeric value for maximum system voltage	System voltage
Temperature	Class Hottest, Hot, Warm, Cool	Use Arrhenius behavior and create maps for rack and roof mounting
Thermal cycling	Class A, B	Thermal cycling comes from changes in irradiance and weather
Humidity	Class Humid, Dry	Average humidity; make map
Snow	Numeric rating for kg of static load	Snow load from local building code
Salt spray	Numeric severity rating	Distance from ocean
Hail	Numeric rating for size of hail ball	Size of hail balls experienced locally
UV	Class A, B	Class A indicates high-altitude or high-irradiance site
Wind	Numeric rating for maximum wind gust	Maximum wind speed seen during gusts
Transportation	Rough/Smooth	Paved/unpaved roads, train, etc.
Farmland	Pass/Fail	Ammonia in agricultural area

Instruction #3 – What level of detail for rating system?

Stress	Rating system	Environmental definition
Voltage	Numeric value for maximum system voltage	System voltage
Temperature	Class Hottest, Hot, Warm, Cool	Use Arrhenius behavior and create maps for rack and roof mounting
Thermal cycling	Class A, B	Thermal cycling comes from changes in irradiance and weather
Humidity	Class Humid, Dry	Average humidity; make map
Snow	Numeric rating for kg of static load	Snow load from local building code
Salt spray	Numeric severity rating	Distance from ocean
Hail	Numeric rating for size of hail ball	Size of hail balls experienced locally
UV	Class A, B	Class A indicates high-altitude or high-irradiance site
Wind	Numeric rating for maximum wind gust	Maximum wind speed seen during gusts
Transportation	Rough/Smooth	Paved/unpaved roads, train, etc.
Farmland	Pass/Fail	Ammonia in agricultural area

When completing instruction #3 (level of detail of testing)

- More levels may be used if:
  - Higher variability of this stress throughout the world (how many climate zones and application variables do we wish to differentiate?)
  - Our ability to distinguish or quantify the meaning of the rating (if we don't understand the failure mechanism, we shouldn't try to be quantitative)

- Two examples of when quantitative tests can be meaningful:
  - Currently the hail test can be passed with different size hail balls. A company that wishes to make a product especially for a hail-prone area can opt to use larger hail balls
  - Currently mechanical load can be passed at different levels, implying an easy way to distinguish products made for heavy snow loads

Instructions to all

1. Discuss list of stresses – do we need to add additional items or cross off any that are there?
   - Poll on entire list or on individual items
2. Discuss general question of rating for each stress versus test results
   - Poll on whether proposed approach of using both is acceptable
3. Discuss level of detail needed relative to each stress (for rating, this could mean number of stars; for test report, it could mean the number of data points recorded)
   - If time permits do poll on each area
4. Prepare summary presentation back to main group