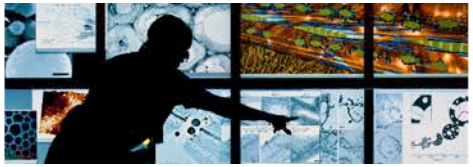
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

International PV QA Task Force (PVQAT)



Sarah Kurtz – representing many people

SOPHIA Workshop

Freiburg, Germany

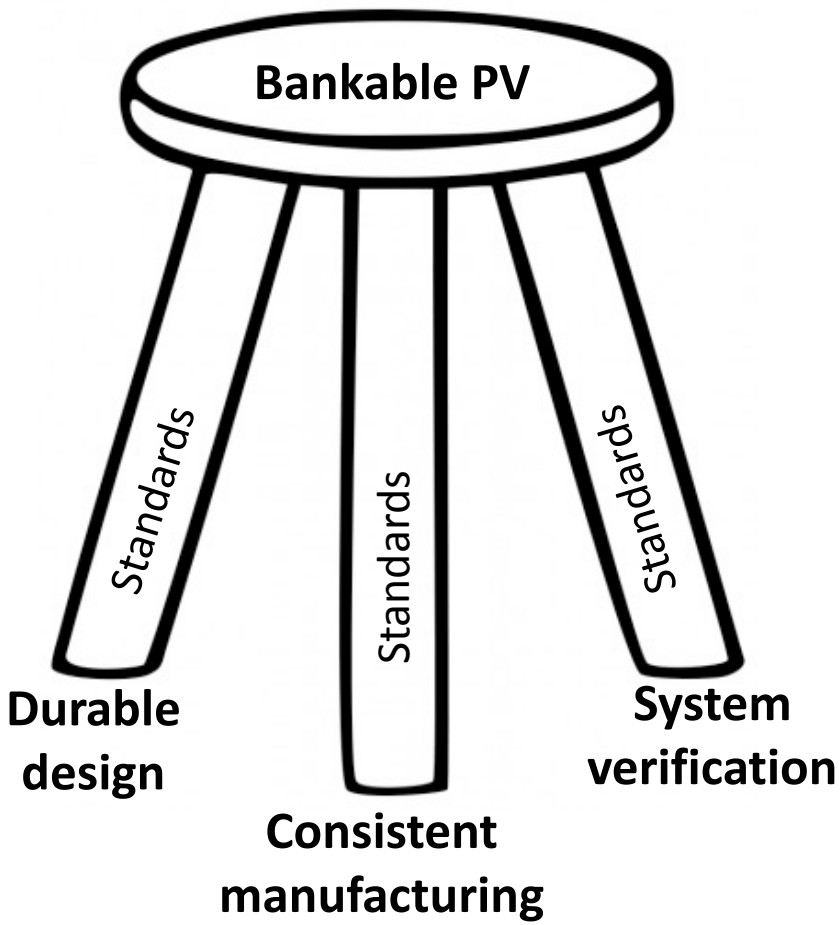
June 3 – 4, 2014

NREL/PR-5J00-62136

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Outline: Three-prong effort plus next steps

1. ***Qualification of durability of design of products*** **for chosen climate and mounting**
2. ***Guide for audit of consistent manufacturing*** **of products built to that design**
3. ***Certification process for system verification*** **to ensure adequacy of design, installation, and operation**



Next goal: Service Life Prediction

Levels of Accelerated Testing

	IEC Qualification	Comparative	Service Life
Purpose	Minimum design qualification	Comparison of products	Reduction of cost while still meeting warranty
Quantification	Pass/fail	Relative	Absolute
Climate or application (mounting)	Not differentiated	Differentiated	Differentiated
Specificity	Silicon, thin-film, CPV	Package specific?	Product specific
Chamber test times	Modules: < 2 months	6 months	3 years ?

Why Differentiate Durability?

- **The reliability engineer prefers a single design**
- **The marketing department desires a product for every customer**
- **Differentiation is valuable:**
  - When it enables a lower cost design for a specific use environment
  - When it quantifies the added value of higher durability (and quality)

1. Durable Design Proposal for Climate-specific rating

PVQAT is developing technical basis for:

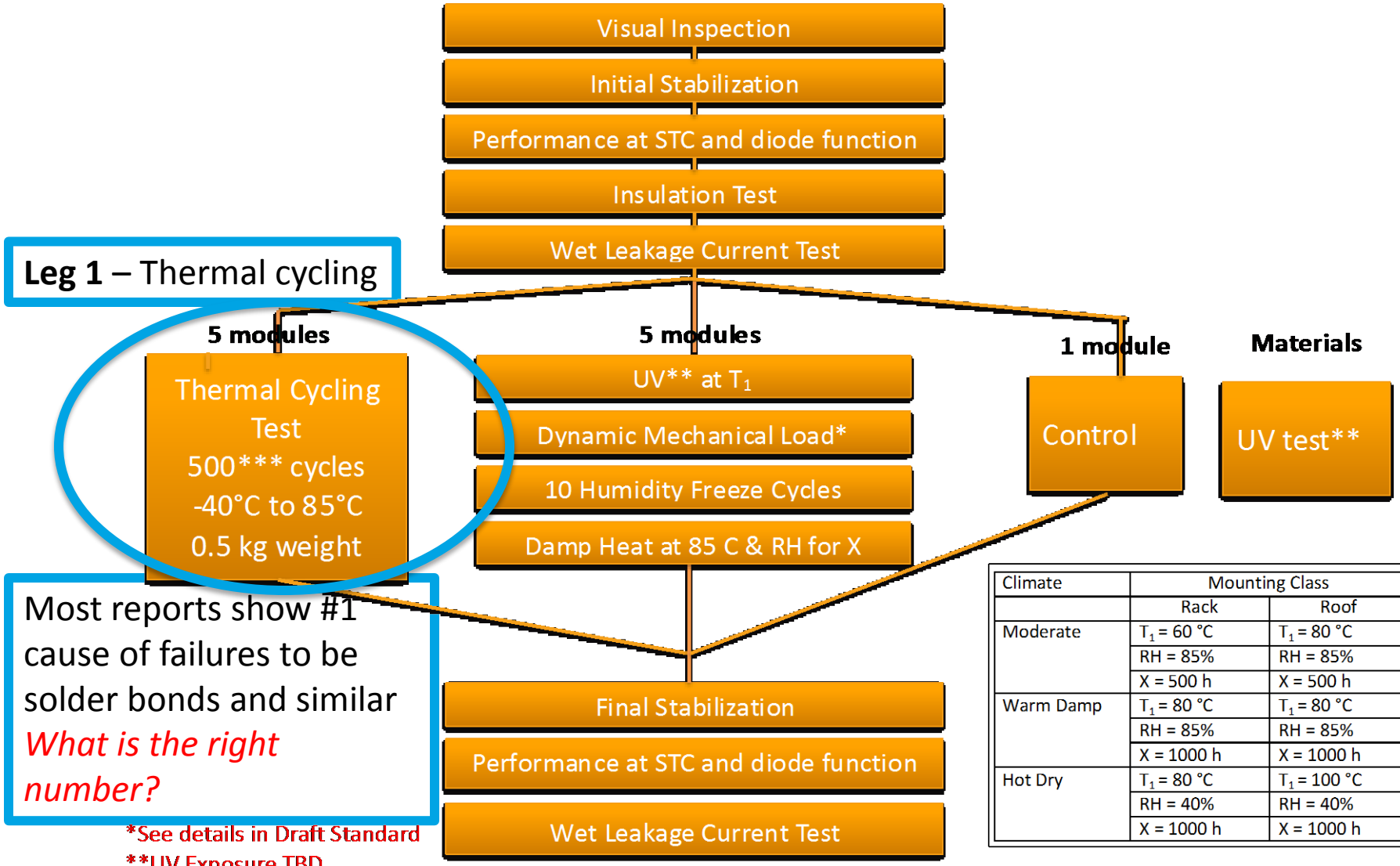
IEC 60721-2-1 Climate Designation	Mounting classes	
	Rack mount	Close-roof mount
Moderate (Temperate)	✔	✔
Warm Damp, Equable (Tropical)	✔	✔
Extremely Warm Dry (Desert)	✔	✔

1. Durable Design – Climate-specific rating

Strawman proposal: details to be debated

IEC 60721-2-1 Climate Designation	Mounting classes	
	Rack mount	Close-roof mount
Moderate (Temperate)	Leg 1: 500 thermal cycles Leg 2: Increased UV exposure at 60 °C followed by 10 cycles of HF and 500 hours of Damp Heat (85/85)	Leg 1: 500 thermal cycles Leg 2: Increased UV exposure at 80 °C followed by 10 cycles of HF and 500 hours of Damp Heat (85/85)
Warm Damp, Equable (Tropical)	Leg 1: 500 thermal cycles Leg 2: Increased UV exposure at 80 °C followed by 10 cycles of HF and 1000 hours of Damp Heat (85/85)	Leg 1: 500 thermal cycles Leg 2: Increased UV exposure at 80 °C followed by 10 cycles of HF and 1000 hours of Damp Heat (85/85)
Extremely Warm Dry (Desert)	Leg 1: 500 thermal cycles Leg 2: Increased UV exposure at 80 °C followed by 10 cycles of HF and 1000 hours of Damp Heat (85/40)	Leg 1: 500 thermal cycles Leg 2: Increased UV exposure at 100 °C followed by 10 cycles of HF and 1000 hours of Damp Heat (85/40)

Two Test Sequences - #1



Climate	Mounting Class	
	Rack	Roof
Moderate	T_1 = 60 °C	T_1 = 80 °C
	RH = 85%	RH = 85%
	X = 500 h	X = 500 h
Warm Damp	T_1 = 80 °C	T_1 = 80 °C
	RH = 85%	RH = 85%
	X = 1000 h	X = 1000 h
Hot Dry	T_1 = 80 °C	T_1 = 100 °C
	RH = 40%	RH = 40%
	X = 1000 h	X = 1000 h

Most reports show #1 cause of failures to be solder bonds and similar

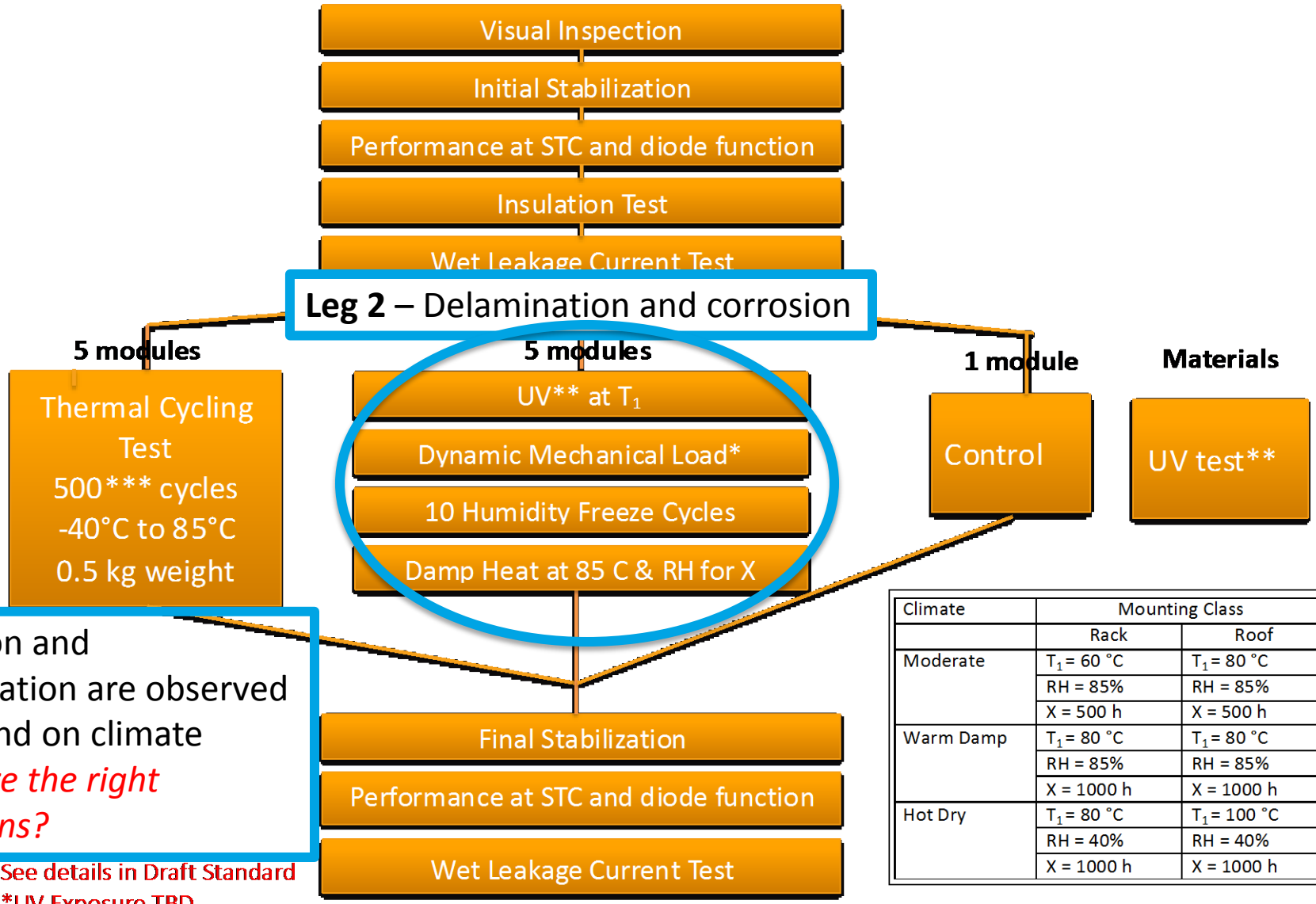
What is the right number?

*See details in Draft Standard

**UV Exposure TBD

***450 forward-; 50 reverse-bias current

Two Test Sequences - #2



Corrosion and delamination are observed to depend on climate

What are the right conditions?

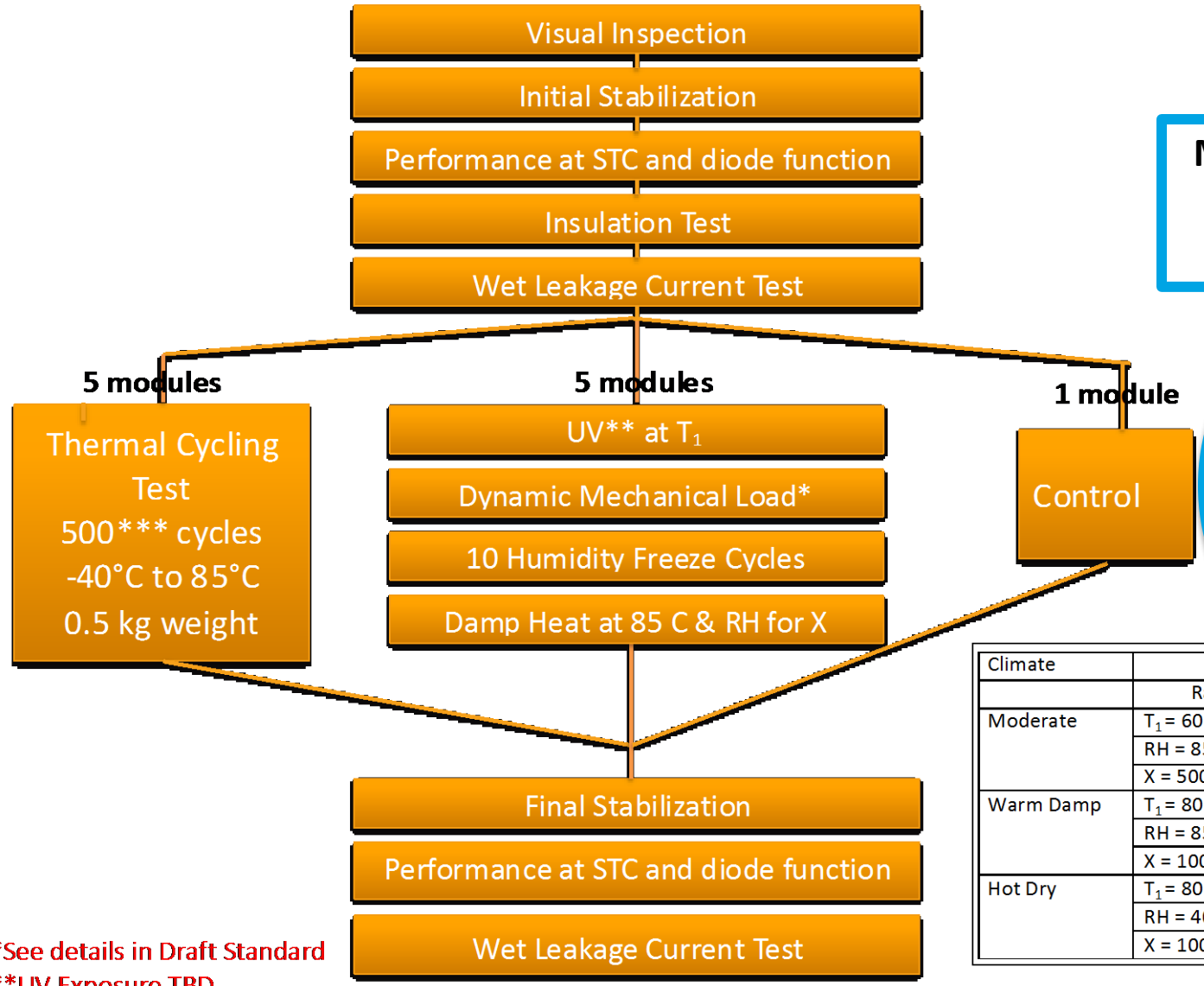
*See details in Draft Standard

**UV Exposure TBD

***450 forward-; 50 reverse-bias current

Climate	Mounting Class	
	Rack	Roof
Moderate	T_1 = 60 °C	T_1 = 80 °C
	RH = 85%	RH = 85%
	X = 500 h	X = 500 h
Warm Damp	T_1 = 80 °C	T_1 = 80 °C
	RH = 85%	RH = 85%
	X = 1000 h	X = 1000 h
Hot Dry	T_1 = 80 °C	T_1 = 100 °C
	RH = 40%	RH = 40%
	X = 1000 h	X = 1000 h

Two Test Sequences – plus material tests



Materials tests may reduce expense

Materials

UV test**

Climate	Mounting Class	
	Rack	Roof
Moderate	T_1 = 60 °C	T_1 = 80 °C
	RH = 85%	RH = 85%
	X = 500 h	X = 500 h
Warm Damp	T_1 = 80 °C	T_1 = 80 °C
	RH = 85%	RH = 85%
	X = 1000 h	X = 1000 h
Hot Dry	T_1 = 80 °C	T_1 = 100 °C
	RH = 40%	RH = 40%
	X = 1000 h	X = 1000 h

*See details in Draft Standard
**UV Exposure TBD
***450 forward-; 50 reverse-bias current

1. Durable Design – Climate-specific rating

IEC 60721-2-1 Climate Designation	Mounting classes	
	Rack mount	Close-roof mount
Moderate (Temperate)	✔	✔
Warm Damp, Equable (Tropical)	✔	✔
Extremely Warm Dry (Desert)	✔	✔

Rating system considers three climates, two mounting classes, *and additional stresses such as snow, wind, hail, salt, sand*

Status: accepted as a proposal by IEC – many details still to be completed: *we need your inputs*!

2. Consistent Manufacturing – PV QMS

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Proposal for a Guide for Quality Management Systems for PV Manufacturing: Supplemental Requirements to ISO 9001-2008

Paul Norum
Amonix

Ivan Sinicco
Tokyo Electron

Yoshihito Eguchi
Japan Electrical Safety and Environment Technology Laboratories (JET)

Sumanth Lokanath
First Solar

Wei Zhou
Trina Solar

Gunnar Brueggemann
Tokyo Electron

Alex Mikonowicz
Powermark

Masaaki Yamamichi
National Institute of Advanced Industrial Science and Technology (AIST)

Sarah Kurtz
National Renewable Energy Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Technical Report
NREL/TP-5200-58940
May 2013

Technical work led by PVQAT

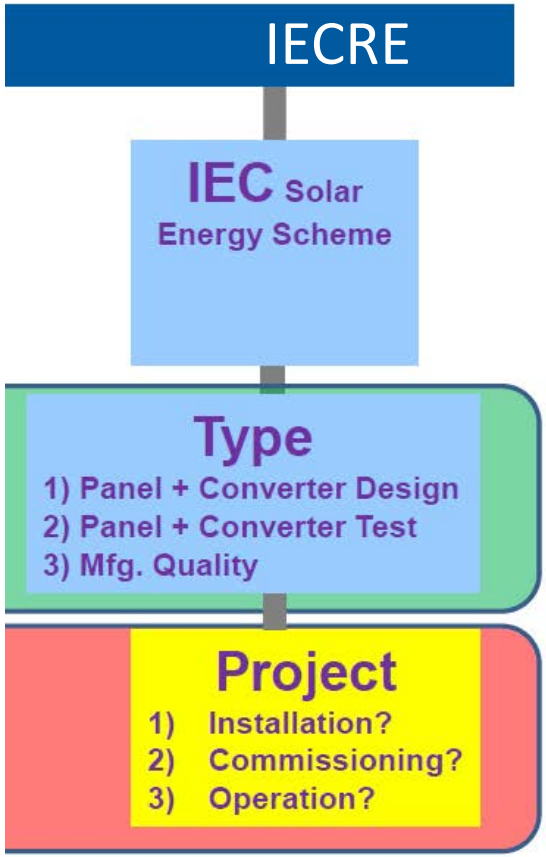
- Guide for PV Quality Management System http://www.nrel.gov/docs/fy13osti/58940.pdf
- Builds on Japanese standard*

- Status: Revised IEC draft to be discussed in Korea
- Goal: IEC Technical Specification in 2015
- Future vision: More detailed version to differentiate QMS

*JIS Q8901-2012 Terrestrial photovoltaic (PV) modules-Requirement for reliability assurance system (design, production, and product warranty)

3. System Verification – IECRE

IEC has formed IECRE for Renewable Energy System verification



PV Standards for testing all aspects of PV Systems:

- Component quality
- System
  - Design
  - Installation
  - Operation
- Training of personnel

PVQAT has formed Task Group 11 to provide input into IECRE, especially as IECRE is getting started
WG3 will be discussing a cluster of documents in Korea

Service Life Prediction Standard?

- **How would you write a standard for making a Service Life Prediction?**
- **The failure mechanisms that limit the life of a product may vary**
- **Current research is providing scientific basis, but we don't have a draft standard yet**

Steps to a Service Life Prediction:

1. Identify failure/degradation mechanisms that determine end of life
2. Quantify kinetic rates
3. For given use environment, apply kinetic rates within model to estimate expected lifetime
4. Verify model by comparing with field data

This step-by-step procedure is clear, but the actual tests are not

This procedure is similar to quality management

Implement Service Life Prediction: QMS

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Proposal for a Guide for Quality Management Systems for PV Manufacturing: Supplemental Requirements to ISO 9001-2008

Paul Norum
Amonix

Ivan Sinicco
Tokyo Electron

Yoshihito Eguchi
Japan Electrical Safety and Environment Technology Laboratories (JET)

Sumanth Lokanath
First Solar

Wei Zhou
Trina Solar

Gunnar Brueggemann
Tokyo Electron

Alex Mikonowicz
Powermark

Masaaki Yamamichi
National Institute of Advanced Industrial Science and Technology (AIST)

Sarah Kurtz
National Renewable Energy Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Technical Report
NREL/TP-5200-58940
May 2013

- The best quality management systems assess whether the product can meet the warranty – this is the best place to quantify Service Life
- A complete Service Life Prediction takes many years to create and verify – most aspects of the product design must be "frozen" first
- Propose (for example) to differentiate with ratings:
  - New product
  - Practiced
  - Mature

Summary of PVQAT Efforts

- **Comparative Rating System:**
  - Three climates, two mounting classes; additional individual stresses
- **Guide for Quality Management Systems**
  - Next steps could be more detailed
- **Support IECRE:**
  - System verification

Summary of Questions

- **Comparative Rating System:**
  - Do we agree on the two legs?
  - Which numbers are controversial?
- **Guide for Quality Management Systems (QMS):**
  - Are we agreed to move to more detailed version that enables differentiation?
- **IECRE:**
  - What should be included?
  - Do we want to define different requirements for utility, commercial and residential type systems?
- **Service Life Prediction:**
  - Should it be part of QMS, alongside of warranty documentation?

Thank you to the PVQAT Task Leaders

- Task Group 1: PV QA guideline for manufacturing consistency — leaders Ivan Sinicco, Yoshihito Eguchi, Govind Ramu, Gunnar Brueggemann, Zhou Wei
- Task Group 2: PV QA testing for thermal and mechanical fatigue including vibration — leaders Nick Bosco, Tadanori Tanahashi
- Task Group 3: PV QA testing for humidity, temperature, and voltage — leaders John Wohlgemuth, Takuya Doi, Neelkanth Dhere
- Task Group 4: PV QA testing for diodes, shading and reverse bias — leaders Vivek Gade, Yasunori Uchida, Paul Robusto
- Task Group 5: PV QA testing for UV, temperature, and humidity — leaders Michael Koehl, Tsuyoshi Shioda, Jasbir Bath, David Miller
- Task Group 6: Communication of PV QA ratings to the community — leaders David Williams and Sarah Kurtz
- Task Group 7: PV QA testing for snow and wind loading — previously, Joerg Althaus
- Task Group 8: PV QA testing for thin-film PV — leaders Neelkanth Dhere, Masayoshi Takani, Veronica Bermudez
- Task Group 9: PV QA testing for Concentrator PV (CPV) — leaders Nick Bosco, Itai Suez
- Task Group 10: Connectors — leader Juris Kalejs
- Task Group 11: QA for PV Systems — leader Sumanth Lokanath.

- George Kelly, and many others