UL

Bifacial Module Certification Requirements

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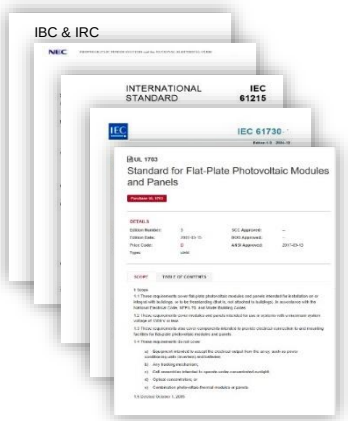
Agenda

- Changing Landscape UL 1703 to UL 61730
- UL 1703 certification requirements
  - CRD July 2018
  - Proposed Revision September 3, 2018
  - Long term
- Safety considerations
  - Electrical Performance
  - Hot Spot Testing
  - Reverse Current Overload
  - Factory Performance
  - Installation and Assembly Instructions

2018 Bifacial Module Workshop

Changing Landscape – Moving from UL 1703 to IEC 61730



International Harmonization Committee

Considerations:

- Codes
- Component Requirements
- Normative References
- Technical Issues
- Permissions
- Other

IHC Process:

Step 1: Proposal and STP Formation

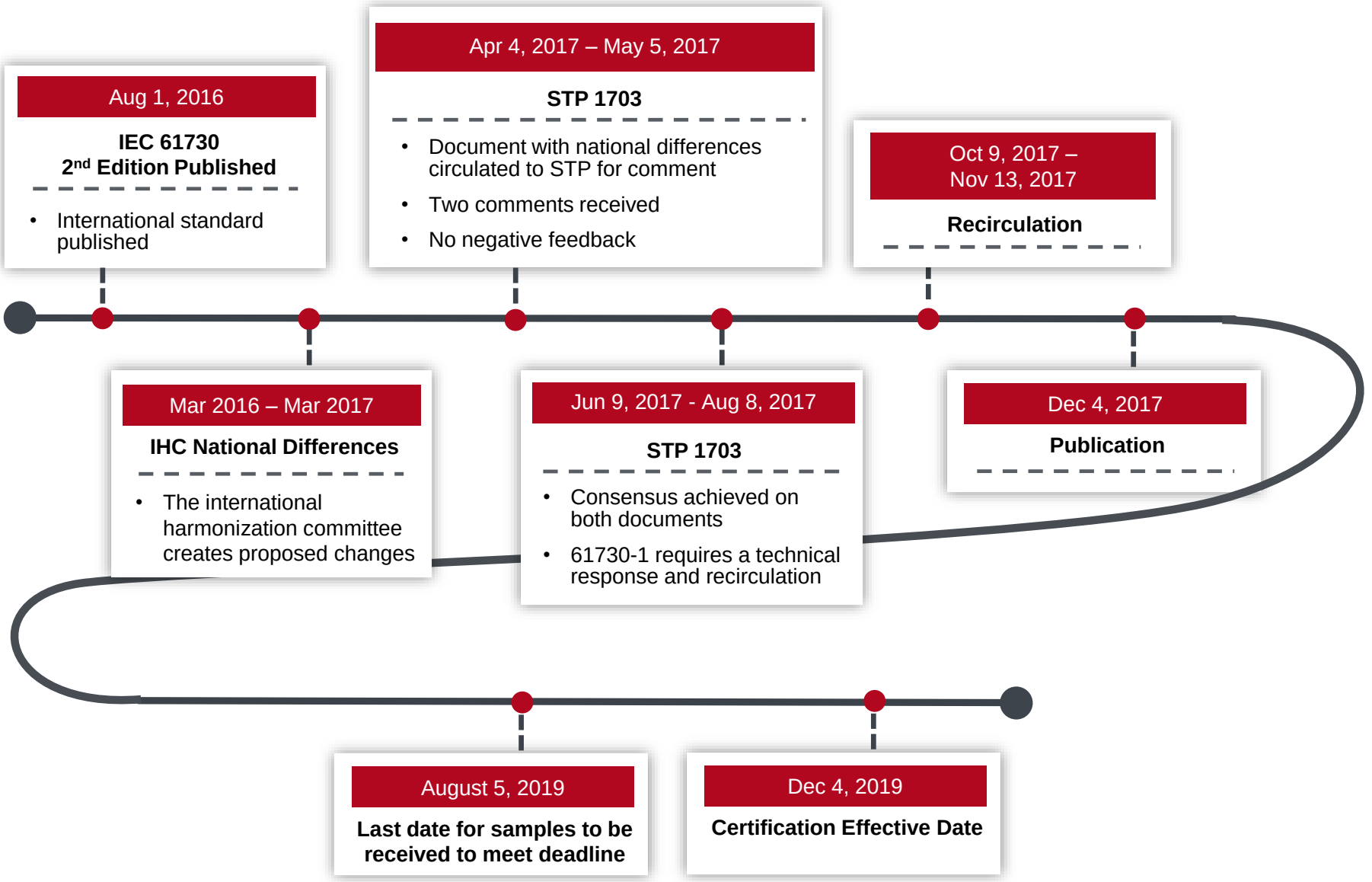
Step 2: STP Comment and Review

Step 3: Balloting and Public Comment

Step 4: STP Consensus and Issuance of Standard

*STP – Standards Technical Panel

Timing


Aug 1, 2016
IEC 61730
2nd Edition Published
• International standard published
Apr 4, 2017 – May 5, 2017
STP 1703
• Document with national differences circulated to STP for comment
• Two comments received
• No negative feedback
Oct 9, 2017 – Nov 13, 2017
Recirculation
Mar 2016 – Mar 2017
IHC National Differences
• The international harmonization committee creates proposed changes
Jun 9, 2017 - Aug 8, 2017
STP 1703
• Consensus achieved on both documents
• 61730-1 requires a technical response and recirculation
Dec 4, 2017
Publication
August 5, 2019
Last date for samples to be received to meet deadline
Dec 4, 2019
Certification Effective Date

What Does This Mean for Existing Certifications?

Continuing Certification

Continuing certification proposed for already certified products

- UL 1703 to continue to exist for compliant products not undergoing significant material or process changes

Evaluation

- Manufacturer may evaluate a product to UL 61730 now
- May also apply UL 1703 up to 5 Aug 2019
- 4 Dec 2019 all new products MUST be evaluated to UL 61730
- Significant changes to products WILL be evaluated using UL 61730 after 4 Dec 2019

UL 1703 CRD through 1703 Standards Revision

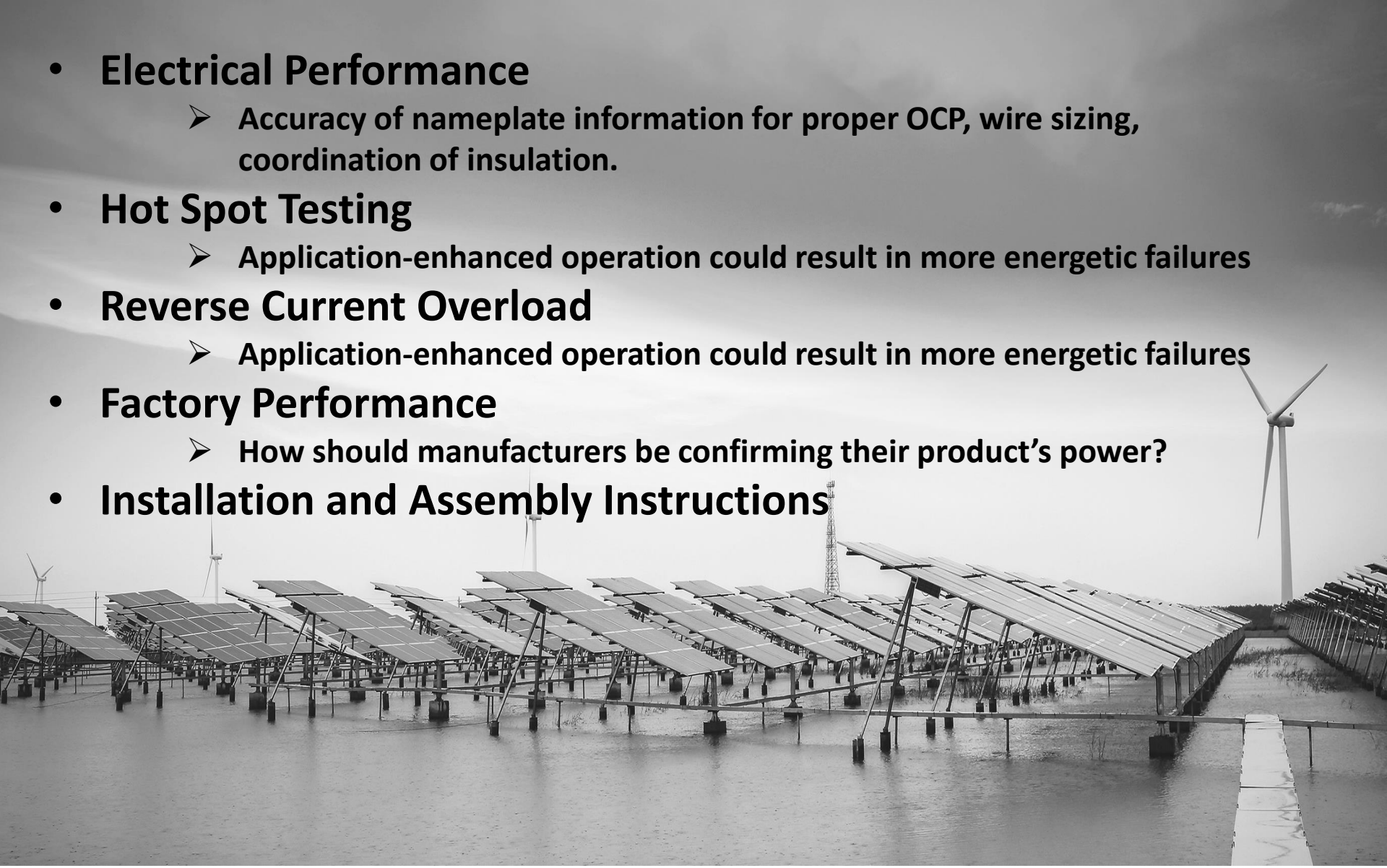
The continuing certification plan means that revisions to UL 1703 will continue until next December.

- Is still THE safety certification for the USA.
- New constructions/issues continue to arise.

Request to add bifacial module requirements occurred last fall (2017) and need to certify equipment led to a Certification Requirements Document (CRD)

UL 1703 Revision September 5, 2018 incorporated these new bifacial requirements.

- **Electrical Performance**
  - Accuracy of nameplate information for proper OCP, wire sizing, coordination of insulation.
- **Hot Spot Testing**
  - Application-enhanced operation could result in more energetic failures
- **Reverse Current Overload**
  - Application-enhanced operation could result in more energetic failures
- **Factory Performance**
  - How should manufacturers be confirming their product's power?
- **Installation and Assembly Instructions**



Main Elements of the Bifacial Requirements

Electrical Performance

Performance to conform to IEC TS 60904-1-2

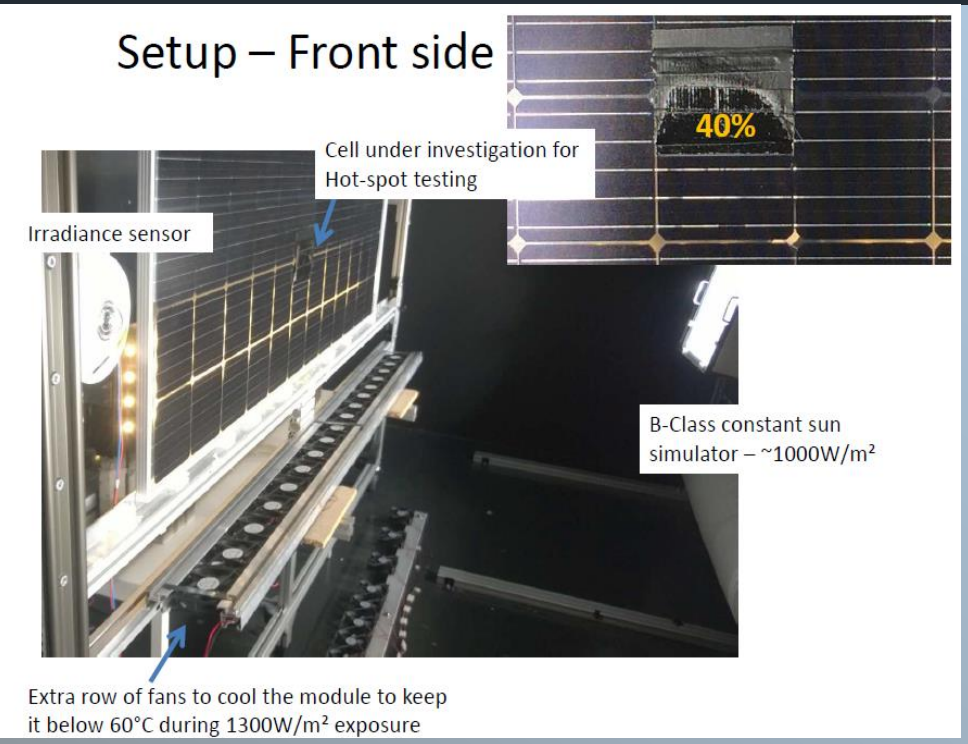
At the time the CRD was issued, WG2 had not published. This did not change when UL 1703 was revised, so 82/1403/DTS is referenced.

Three methods are allowed for TS 60904-1-2 and all three may be used in UL 1703 certifications.

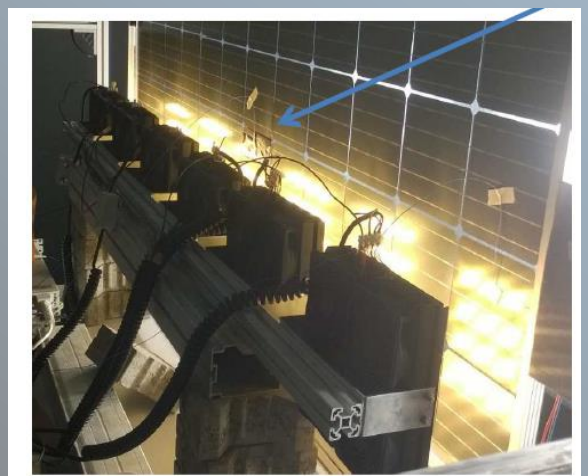
- **Single-sided solar simulators (must be capable of up to 1300 W/m^2)**
- **Double-sided solar simulators**
- **Natural sunlight**

- **Ratings match nameplate to ±10% or stated tolerance if tighter**
- **Shock at the product level considered at -20°C, 1kW/m^2**
- **Power and Imax also reported at NOCT (still)**

Hot Spot



- Discussions with manufacturers led to
  - Data showing that 127% additional current (from a mono-facial equivalent) possible under favorable conditions of:
    - Row-to-row spacing
    - Ground reflectivity
    - Unobstructed racking
- 130% Selected for Fault Considerations
  - Points to IEC 61215-2 Cl 4.9.4
  - Test at 1300 W/m^2 frontside or 1000 W/m^2 front, 300 W/m^2 backside irradiance.
  - Have performed this both with front-side only and front/back irradiance.

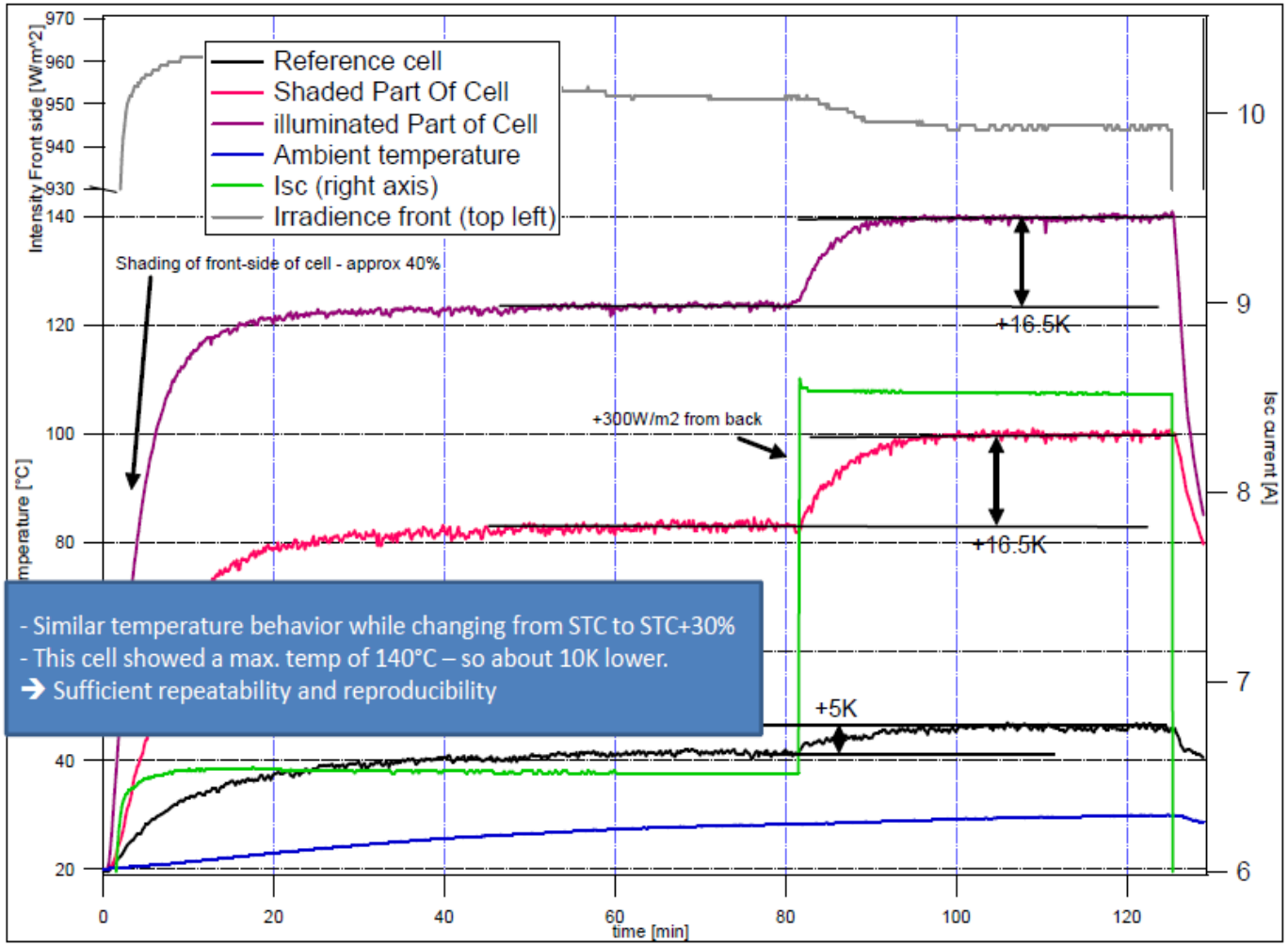


Hot Spot: What do results look like?

Generally, the risk of a hot spot failure in a one surface shading scenario appears to be mitigated in bifacial modules. No failures observed.

Maintaining module temperature within IEC 61215 50°C ± 10°C does require fan cooling with a continuous simulator.

Multi-sample testing showed reproduceable results.



Requirements:

No major defects created

No reduction in wet leakage current readings.

Reverse Current Overload

The hazard is no different with bifacial, but the variable nature of the current – tied to installation and surroundings – makes the fuse sizing important.

$$I_{fuse} = 1.25 \times 1.25 \times I_{sc}$$

Requirement:
No indication of a fire hazard as a result of this test.

Reverse Current Overload

Maximum Power	(Pmax)	340W
Maximum Power Voltage	(Vmp)	38.7V
Maximum Power Current	(Imp)	8.79A
Open Circuit Voltage	(Voc)	47.2V
Short Circuit Current	(Isc)	9.40A
Maximum Series Fuse		15A
Power Selection		0~5W
Module Application		Class A

Front Side Only Ratings Have Been Seen! (above)

In this example from a Tier 1 manufacturer:

$$I_{fuse} = \overset{\text{wire}}{1.25} \times \overset{\text{irradiance}}{1.25} \times \overset{\text{Isc}}{9.40} \times \overset{\text{backside}}{1.3} = 19A$$

Even with a ϕ_{Isc} of 80% this is above 15A, so NEC says 20A

- Step 1 – Size the fuse appropriately
- Step 2 – Demonstrate safety of module at this fuse size through the RCO test.

Requirement:
No indication of a fire hazard as a result of this test.

Factory Performance

100% Production Requires IV testing per TS 60904-1-2

Exception: Front or back-only power measurement allowed, but periodic sampling to TS 60904-1-2 required

	Electrical and Module Fire Class and Type Ratings							
Cat. No.	I_{sc}	V_{oc}	P_{max}	Max System V dc	Series Fuse Rating (A)	Module Fire Class	Module Fire Performance Type Rating	Application Class*
Photovoltaic module frontside STC rating								
YL350CG2536F-1 *(Report Date: 2018-04-28)*	9.56	44.9	315	1500	20	C	3	N/A
YL355CG2536F-1 *(Report Date: 2018-04-28)*	9.59	45.2	320	1500	20	C	3	N/A
YL360CG2536F-1 *(Report Date: 2018-04-28)*	9.62	45.4	325	1500	20	C	3	N/A
Photovoltaic module STC bifaciality coefficients, Φ								
YL350CG2536F-1 *(Report Date: 2018-04-28)*	81.5%	99.3%	82.0%	—	—	—	—	—
YL355CG2536F-1 *(Report Date: 2018-04-28)*	81.5%	99.3%	82.0%	—	—	—	—	—
YL360CG2536F-1 *(Report Date: 2018-04-28)*	81.5%	99.3%	82.0%	—	—	—	—	—

Requirements: Matches certification performance (left) within stated tolerance.

Documentation – Installation Instructions

- Shall include the electrical ratings for both front and back surfaces (Bifaciality Coefficient)
- The expected contribution from ground reflected irradiance along with ground cover and
- Installation height above ground that reflected irradiance is consistent with.
- *Bifacial modules shall also advise users of specific application conditions that could result in higher power output requiring special consideration.*

Summary

- PV modules transitioning to IEC-style safety certification in the US using UL 61730.
- UL 1703 will continue and bifacial requirement in this document now.
- Safety considerations
  - Electrical Performance -> points to IEC TS 60904-1-2
  - Hot Spot Testing -> points to IEC 61215-2 CL 4.9
  - Reverse Current Overload-> Fuse size!
  - Factory Performance -> Single-sided allowed
  - Installation and Assembly Instructions ->Provides user with some guidance for performance expectations.

Thank you!