PowerMark Corporation

Photovoltaic Module and Component Certification Program

NREL Transforming ENERGY

Revision of the PV Module Qualification Standard (IEC 61215)

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NIST/UL Workshop on Photovoltaic Materials Durability

December 13, 2019

61215 New Edition Project Team

Thanks to the project team for crafting an internationally "owned" standard!

- 61 Members
- 12 Countries
- 44 Companies / Organizations

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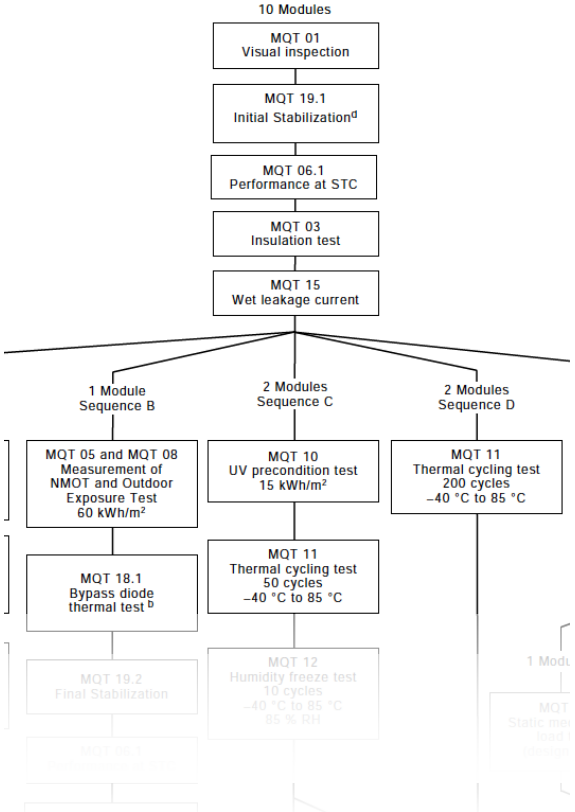
Outline

1. Overview of existing IEC 61215: 2016
2. Schedule of the new edition in progress
3. Some of the planned technical changes in the new edition
   - Procedures for bifacial modules
   - Addition of dynamic mechanical load test
   - Addition of potential induced degradation test
   - Simulator requirements
   - Use of representative samples
   - New Stabilization for Boron-Oxygen Light Induced Degradation (B-O LID)
   - Light and Elevated Temperature Degradation (LeTID): A separate technical specification
   - Additional changes

Existing IEC 61215 Series for PV Module Design Qualification

- Small sample set: 10 modules
- Sequence of accelerated stress tests that have been empirically related to field failures.

Are modules of this design likely to last?



Existing IEC 61215 Series for PV Module Design Qualification

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- Sequence of accelerated stress tests that have been empirically related to field failures.
- Evaluate whether performance matches label (“gate 1”) and whether there is 95% performance retention after stress (“gate 2”).

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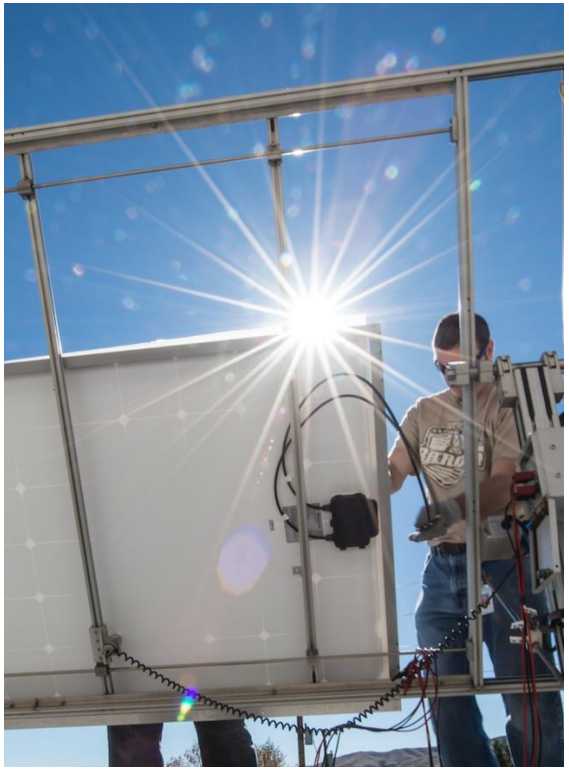

Existing IEC 61215 Series for PV Module Design Qualification

Are modules of this design likely to last?

- Small sample set: 10 modules
- Sequence of accelerated stress tests that have been empirically related to field failures.
- Evaluate whether performance matches label (“gate 1”) and whether there is 95% performance retention after stress (“gate 2”).
- Six documents (61215-###) describe general requirements, test flows, test procedures and apparatus, and small differences needed to implement some tests for different cell technologies.

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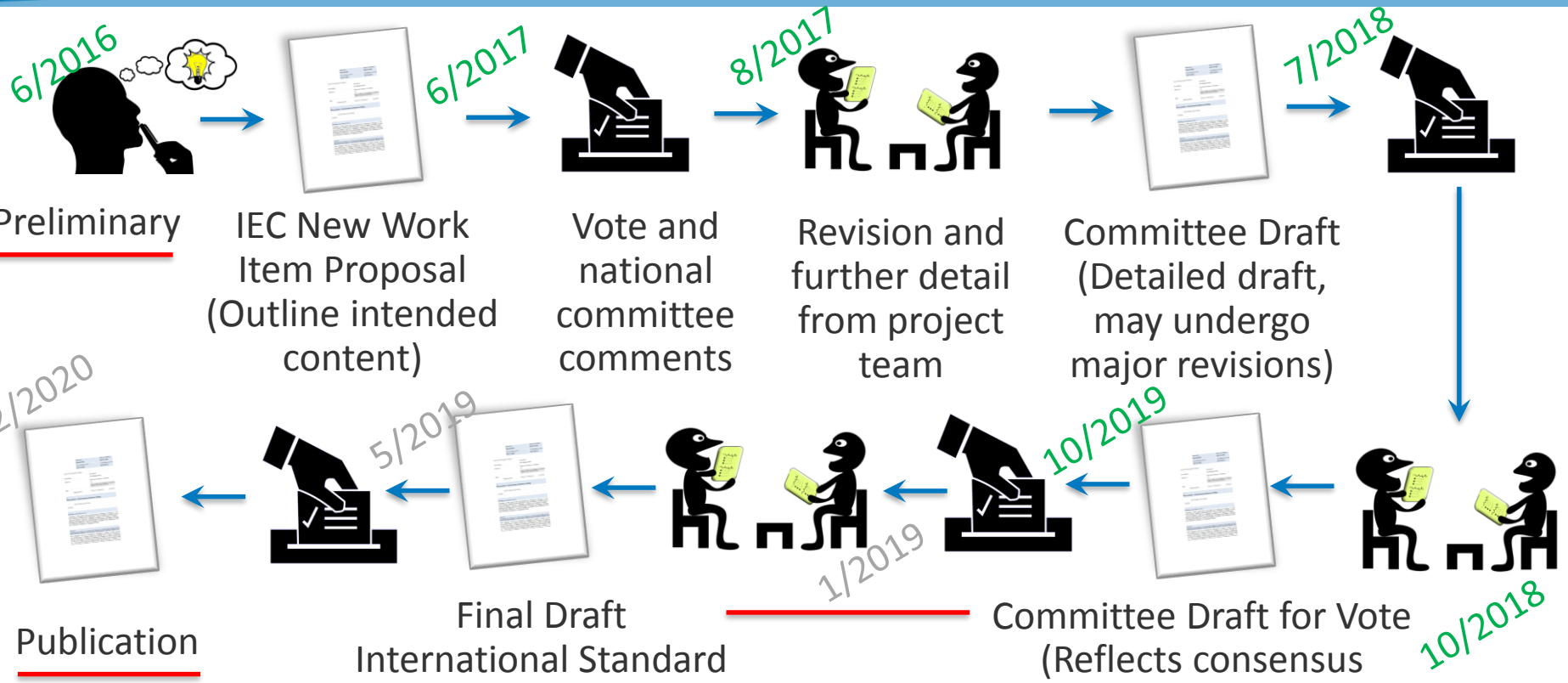
Schedule, Document Stages, and Status



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Procedures for Bifacial Modules – Performance Verification

- **Bifacial modules are qualified under IEC 61215:2016 as if back side produces no power.**
- **New edition - Gates 1 and 2 are performed at two irradiances: STC, and with 135 W/m² on backside.**
- **135 W/m² rear irradiance is based on published studies involving typical albedos and row spacings.**
- **Measurements may be made using any method, one-sided or two-sided, prescribed in IEC TS 60904-1-2 (published 29 Jan 2019).**

New edition will check this and apply higher current during stress tests

IEC 61215-2:2016 tests only this

Electrical Specifications	Specifications Including Backside Irradiation Contribution in ISC as a Percent of STC					
	STC[1]	5%	10%	15%	20%	25%	30%
Rated Power (Pmax)[1]	190 W	199 W	208 W	216 W	225 W	234 W	243 W
Maximum Power Voltage (Vpm)	55.3 V	55.30 V	55.36 V	55.42 V	55.50 V	55.52 V	55.56 V
Maximum Power Current (Ipm)	3.44 A	3.60 A	3.75 A	3.91 A	4.06 A	4.22 A	4.37 A
Open Circuit Voltage (Voc)	68.1 V	68.3 V	68.4 V	68.5 V	68.6 V	68.6 V	68.8 V
Short Circuit Current (Isc)	3.7 A	3.89 A	4.07 A	4.26 A	4.44 A	4.63 A	4.81 A

Procedures for Bifacial Modules – Applied Stress Conditions

- **In the 61215 new edition, where measured current determines applied stress level, a higher current is used.**
- **The higher current is that measured with near worst-case rear irradiance of 300 W/m^2.**

Stress	Test # (MQT)	Level for Monofacial Module	Level for Bifacial Module
Thermal Cycling	11	Imp@STC	Imp@(STC+ 300 rear)
Bypass Thermal Diode Test	18.1	Test Current = 1.25 x Isc@STC	Test Current = 1.25 x Isc@(STC + 300 rear)
Bypass Diode Functionality Test	18.2	Test Current = 1.25 x Isc@STC	Test Current = 1.25 x Isc@(STC + 300 rear)
Hot Spot Endurance	09	1000 W/m^2	1000 W/m^2 on front and 300 W/m^2 on rear; or (1000 + φ·300) W/m^2 if applied one-sided
UV Exposure	10	Front side only	Front then rear side

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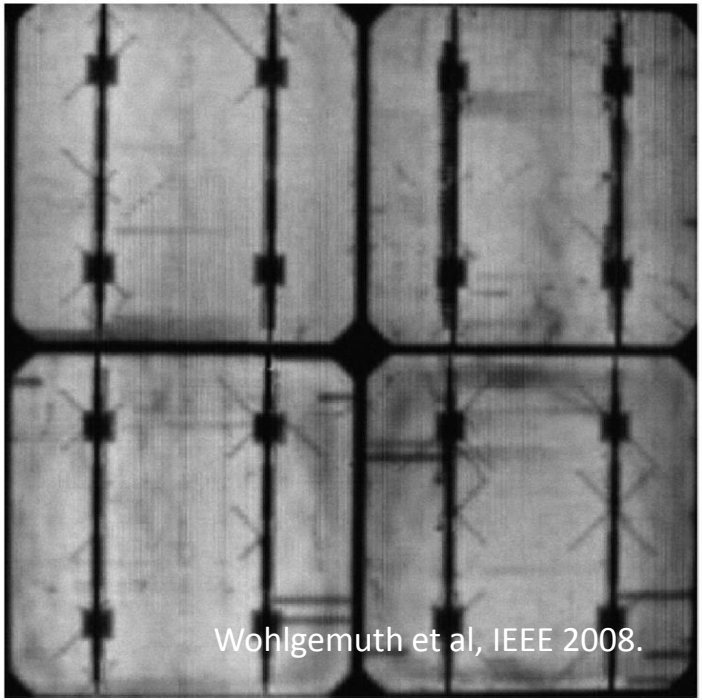
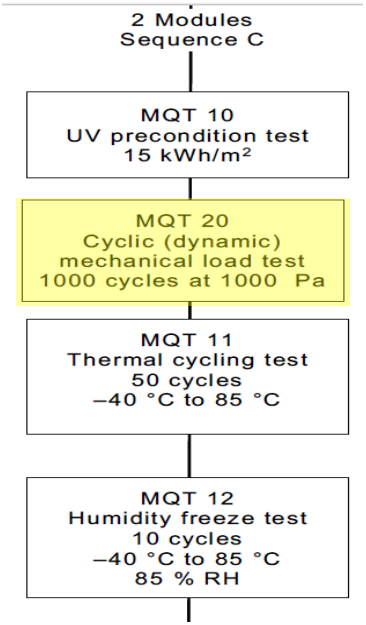
Addition of Dynamic Mechanical Load (DML) Test



- Tests for extreme susceptibility to mechanical stress. (E.g. cells that are already cracked at left.)
- 1000 Pa for 1000 cycles, based largely on BP data.
- Enough force and repetition to detect pre-existing problems.
- It is *not* a module abuse test.
- Test is added in. sequence C, between UV and thermal cycling
- Test is taken from IEC TS 62782.



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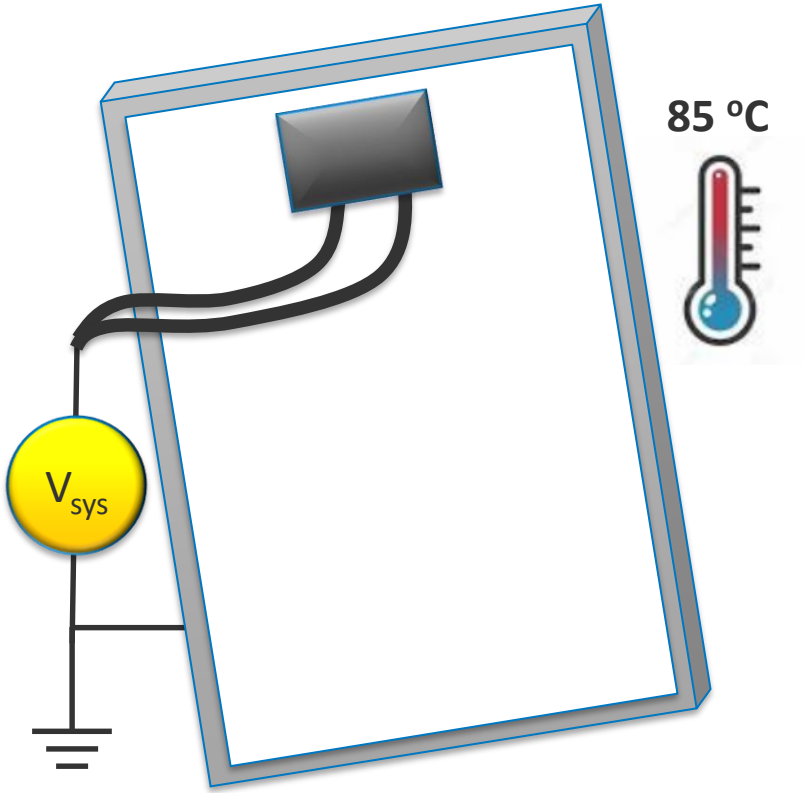
Include PID Test from IEC TS 62804-1

- Two modules per allowed voltage polarity are stressed at maximum system voltage (V_{sys}).
- Looking for degradation via Na migration from the glass into the cell.
- Stress level is 85 °C, 85% relative humidity, 96 hours – harshest of 3 levels defined in 62804-1.
- The PID test for Si is estimated to produce effects similar to ~20 years exposure in a climate like Florida – less than a standard warranty period.
- The most susceptible designs from each device technology fail.



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Simulator Requirements – Why Change?

Three simulator options for power measurement in 61215:2016

Class AAA simulator

(A Really Good Simulator)

BBA simulator + reference module of same size and cell technology

(A Really Good Reference Module)

Spectral responsivity of module + BBA simulator spectral data

(Really Good Data)

- **Module fill factors are increasing (larger impact from spatial nonuniformity)**
- **Larger variety of class A simulator spectra, particularly with use of LED's**
- **Today's technology makes low total uncertainty possible, but published standard does not specify a requirement**

Reminder: CBA = class C wavelength distribution, class B uniformity, class A stability

Simulator Requirements – Uniformity

Class AAA simulator

(A Really Good Simulator)

A

BBA simulator + reference module of same size and cell technology

(A Really Good Reference Module)

Spectral responsivity of module + BBA simulator spectral data

A

(Really Good Data)

- **Module fill factors are increasing (larger impact from spatial nonuniformity)**
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Simulator Requirements – Spectral Class

Must quantify or control spectral mismatch error.

~~Class AAA simulator~~

(~~A Really Good~~ Simulator)

~~A~~ ~~C~~ ~~BBA~~ simulator + reference module of same ~~size~~ and cell technology

(A Really Good Reference Module)

Spectral responsivity of module + ~~BBA~~ simulator spectral data ~~A~~ ~~C~~

(Really Good Data)

- Module fill factors are increasing (larger impact from spatial nonuniformity)
- Larger variety of class A simulator spectra, particularly with use of LED's
- Today's technology makes low total uncertainty possible, but published standard does not specify a requirement

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Simulator Requirements – Allowable Uncertainty

Upper limits on gate 1 uncertainty (m_1) are stated in technology-specific parts: 3.0% for x-Si, 4.0% single-junction thin film, 5.0% for multi-junction thin film.

~~Class AAA simulator~~

(~~A Really Good~~ Simulator)

~~A~~

~~C~~ ~~BBA~~ simulator + reference module of same ~~size~~ and cell technology

(A Really Good Reference Module)

Spectral responsivity of module + ~~BBA~~ simulator spectral data ~~A~~ ~~C~~

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- **Module fill factors are increasing (larger impact from spatial nonuniformity)**
- **Larger variety of class A simulator spectra, particularly with use of LED's**
- **Today's technology makes low total uncertainty possible, but published standard does not specify a requirement**

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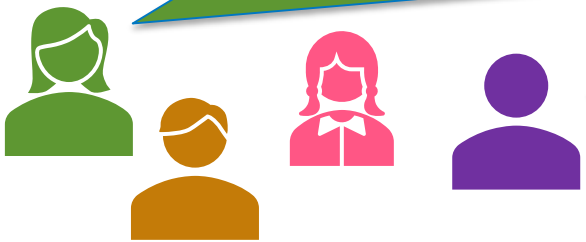
61215 Procedures Are Used in Many Ways

My manufacturing quality assurance program specifies using 61215 IV measurement procedures. The spectral match requirement is too much!



I require that warranty claims be evaluated using 61215 IV measurement procedures. The class A uniformity is too much!

- **However, 61215 is designed for certification, performed by certified test labs**
- **One document cannot suit all users. Notes were added to this effect.**
- **In the longer term – There may be a need for an IEC document that sets out different requirements for different applications.**

NOTE: Lesser requirements, such as use of CAB class simulators, may be appropriate for other applications, such as quality control in the factory.

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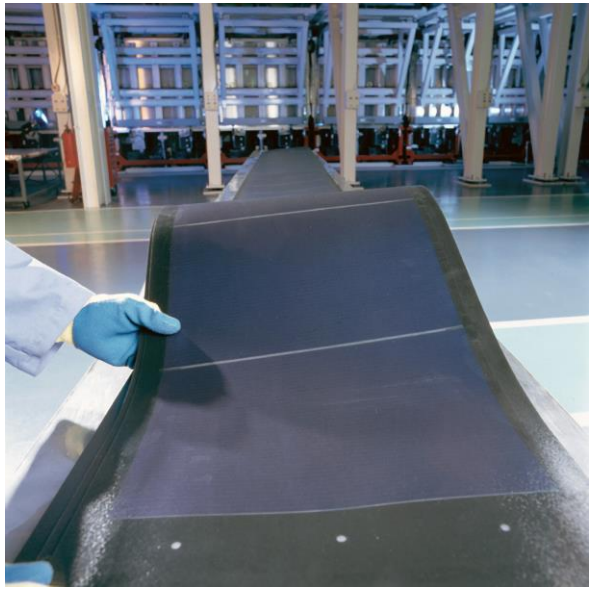
Use of “Representative Samples”

- A small fraction of new products anticipated for qualification are much larger than typical test equipment.
- Requiring a test lab to obtain custom test equipment for one product is expensive and would create an unfair barrier to certification.
- Thus, representative samples may be used for applying stress and evaluating gate 2 on very large modules.
- Eligible modules are those that will not fit on typical large commercially-available AAA simulators. (2.6 m x 2.1 m)



- Reduced dimension(s) shall be no less than one half those that define an eligible module. (Thus one-cell mini-modules, for example, are NOT acceptable for qualification testing.)
- A full-sized sample is still required for nameplate verification (gate 1).

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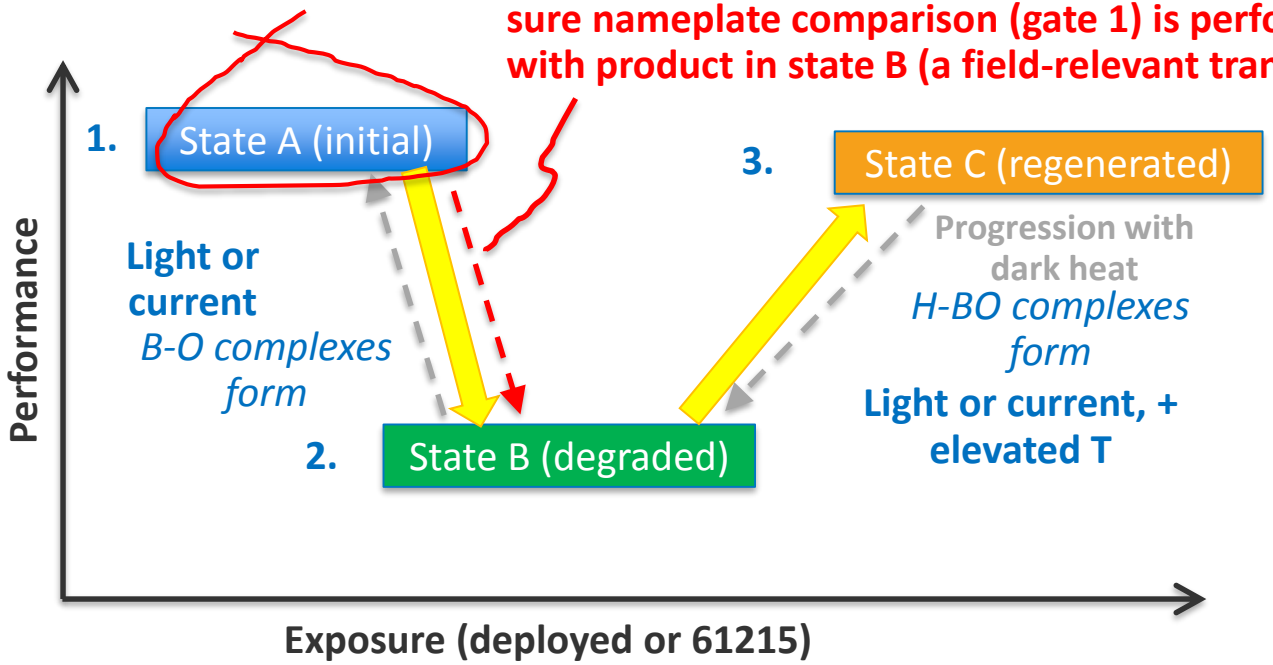
Simplified Schematic of B-O LID Behavior

Previous generations of products were often shipped in state "A"

MQT 19.1 stabilization (light soak) is used to make sure nameplate comparison (gate 1) is performed with product in state B (a field-relevant transition)

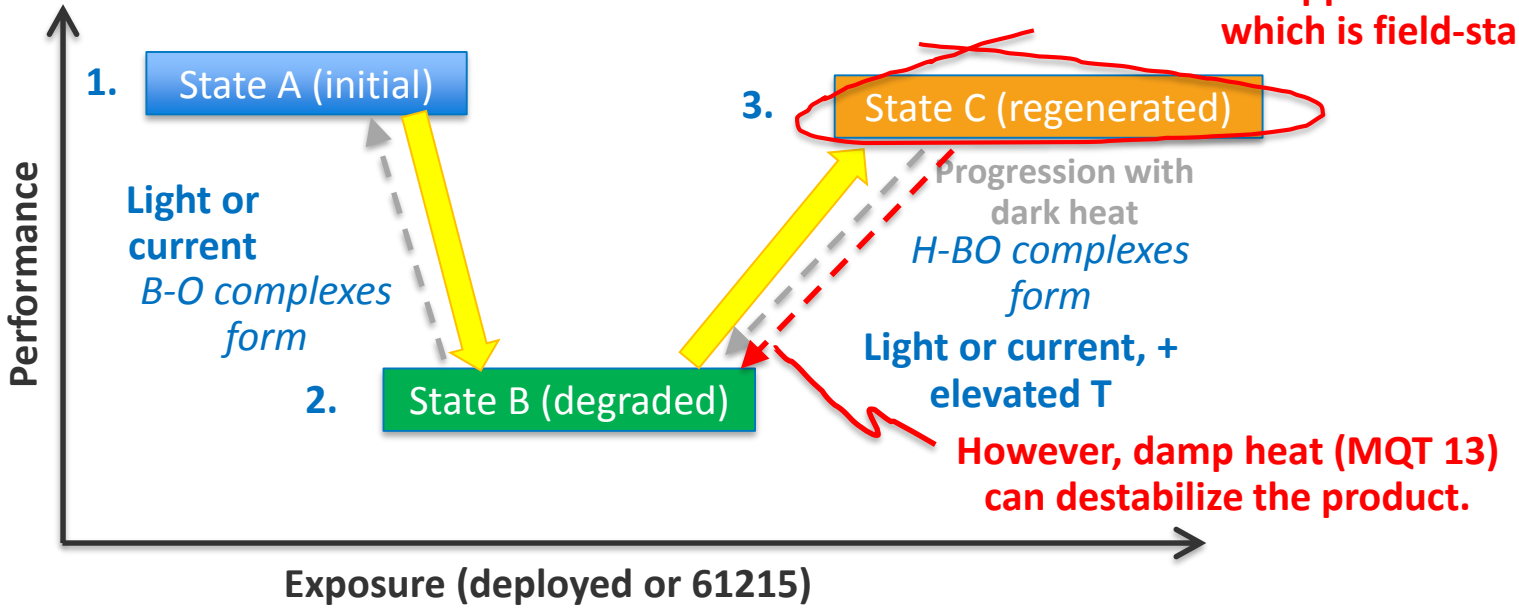


- Heat and excess carriers accelerate yellow processes.
- Gray processes are slower, but don't need excess carriers.
- The gray processes are not field-relevant, since they require dark heat.

Need for New Type of B-O LID Stabilization

Destabilization can produce a false negative in MQT 13.

Recently, many products are shipped in state "C," which is field-stable



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- Gray processes are slower, but don't need excess carriers.
- The gray processes are not field-relevant, since they require dark heat.

New Type of B-O LID Stabilization

- **The new edition includes an optional B-O LID stabilization after damp heat to avoid the worst consequence associated with destabilization – a false failure.**
- **Current (I_{sc}) is applied during dark heat (85 ^{o}C) for 48 hours.**
- **Procedure is based on a published study by Kersten et al: https://doi.org/10.1063/1.5123869**

4.18.7 Stress-Specific Stabilization – BO LID (MQT 19.3)

Some stress conditions may change the state of semiconductor defects in a way that is not representative of field behavior and is not related to the degradation mechanisms that are targeted by the stress tests. In this case, a stress-specific stabilization may be required to set the defects into a reproducible state either before or after stress. When to apply a stress-specific stabilization is prescribed in the technology-specific parts.

MQT 19.3 describes an optional stabilization procedure that puts the defects causing boron-oxygen light induced degradation into the regenerated state. It shall only be used at points in the test flow specifically allowed in 61215-1-1.

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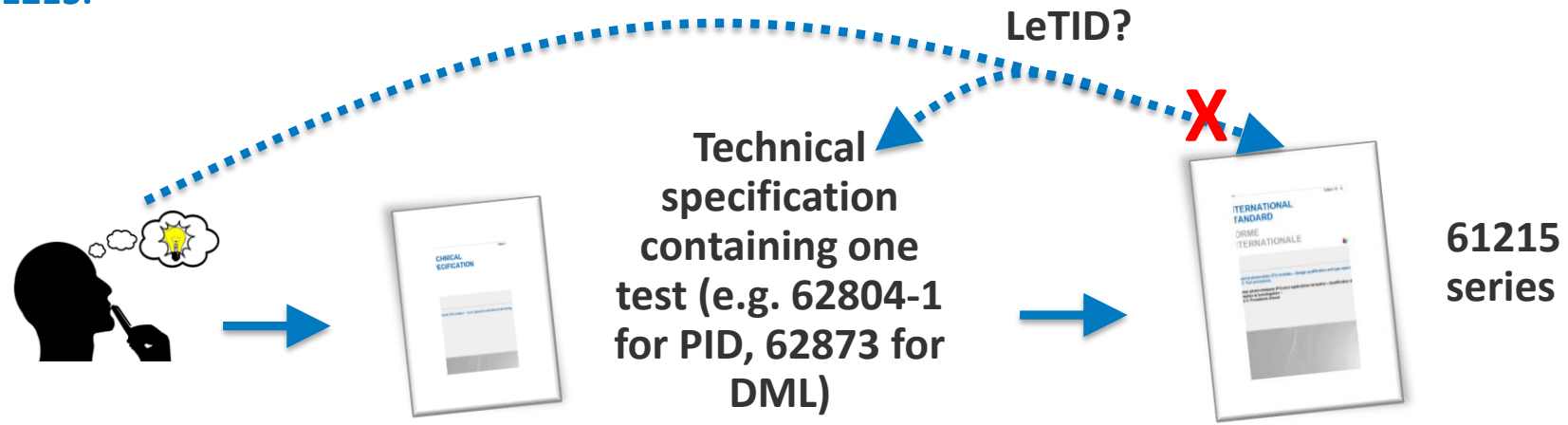
Proposed LeTID Test Will be a Separate Technical Specification

- The usual progression for introducing a new test into 61215 is to develop a separate technical specification (TS) first.
- However, in 2018, IEC working group 2 felt that addressing LeTID is urgent, and it should be attempted to introduce a LeTID test directly into the 61215 new edition.
- Developed procedure. Evaluating its maturity via international collaborative study.
- This year, working group 2 recommended that the LeTID test be moved to a separate TS, because: 1) Most who use the test would like an analog result, not a pass-fail, to help quantify the effect on energy generation; 2) The test is still relatively immature compared to others in 61215.



Additional Changes to 2nd Edition

- Special requirements for flexible modules
- Using weights during Thermal Cycling to evaluate J-box adhesion
- Deleting NMOT measurement
- Correcting hot spot test for MLI
- Modifying insulation test – both how it is done (back to old way) and the pass/fail to make that consistent with IEC 61730
- Gate 1 becomes statistical and allows 1 failure when testing more than 10 modules.


Thank
you!