Items coming over the horizon for testing of reliability of PV modules

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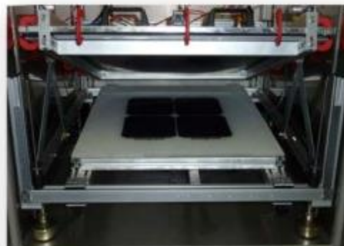
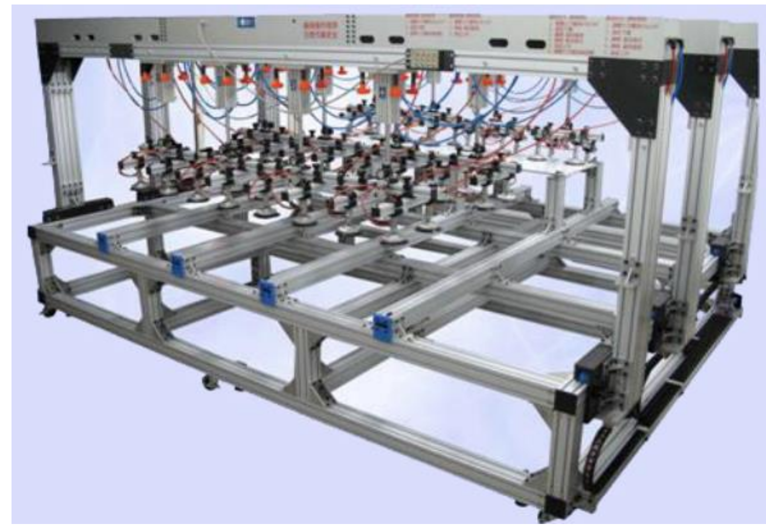
Cyclic dynamic load

- cyclic (dynamic) loading: this equipment shall be capable of applying a uniform load of 1 000 Pa ± 100 Pa onto the module surface in both directions to simulate pressure and tensile loads at a rate between 3 and 7 cycles per minute. 1 000 times

From IEC TS 62782:2016 into next edition of 61215



- Custom built mechanical test stand for load testing in environmental chamber
  - Uniform load profile using inflatable bladder
  - Loading up to ~ 10,000 Pa
  - Capable of dynamic (cyclic) loading at up to ~ 1 Hz
  - Test module dimensions up to 550 mm x 550 mm



NREL considers the bladder method better. You need a lot of pistons and cups for the piston method.

a) If the cyclic (dynamic) mechanical load testing breaks cells and/or interconnect ribbons, subsequent exposure to 50 thermal cycles (MQT 11 from IEC 61215-2) and 10 humidity freeze cycles (MQT 12 from IEC 61215-2) can lead to significant loss in peak power.

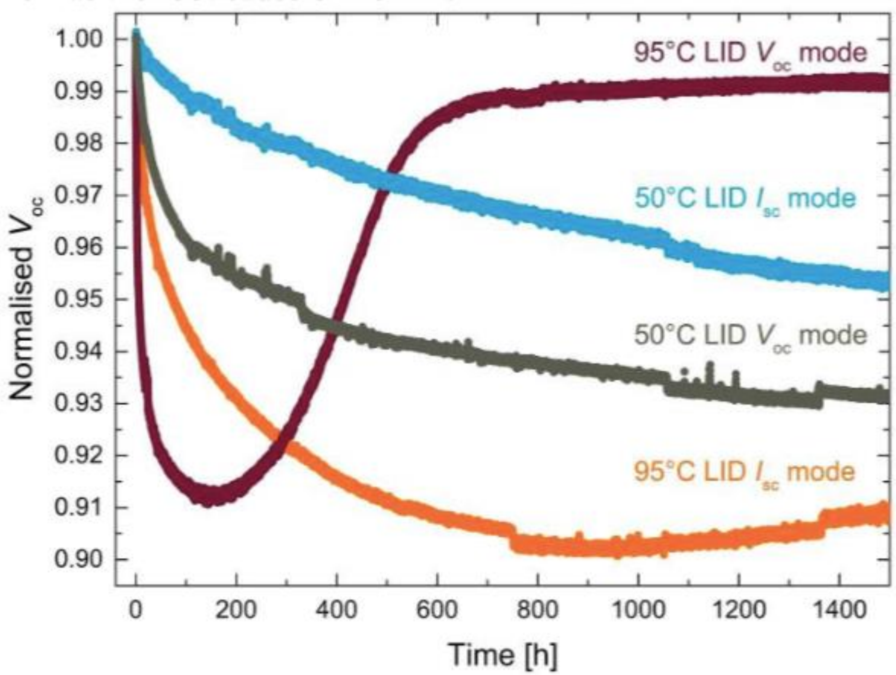
b) If the cyclic (dynamic) mechanical load testing damages the module's edge seal, subsequent exposure to damp heat testing (MQT 13 from IEC 61215-2) could result in moisture ingress and subsequent power loss.

Therefore, this technical specification can be used in conjunction with additional accelerated stress tests to evaluate the overall impact on module performance.

Light and elevated temperature induced : LeTID

Newly devised, aiming to get into 61215

75± 3 °C, turn on the power supply and subject the modules to I_{sc}- I_{mp} for 162h. During the test the maximum and minimum temperatures should be within

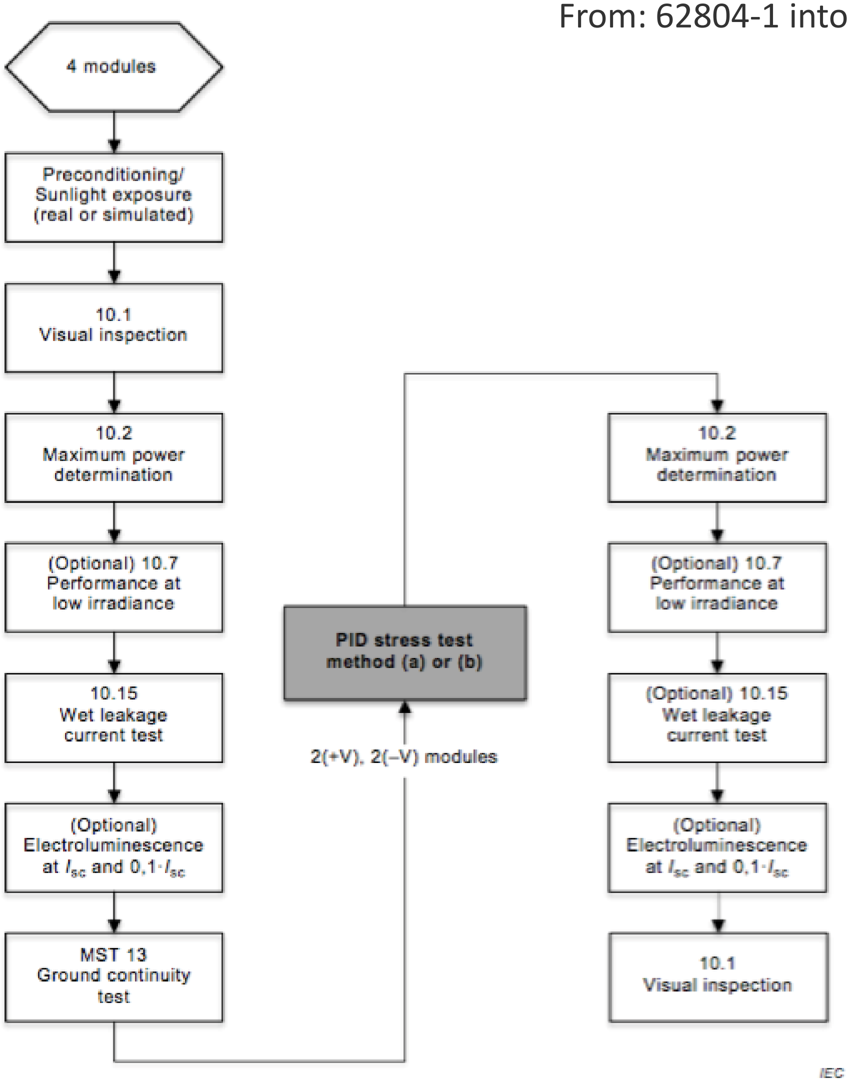


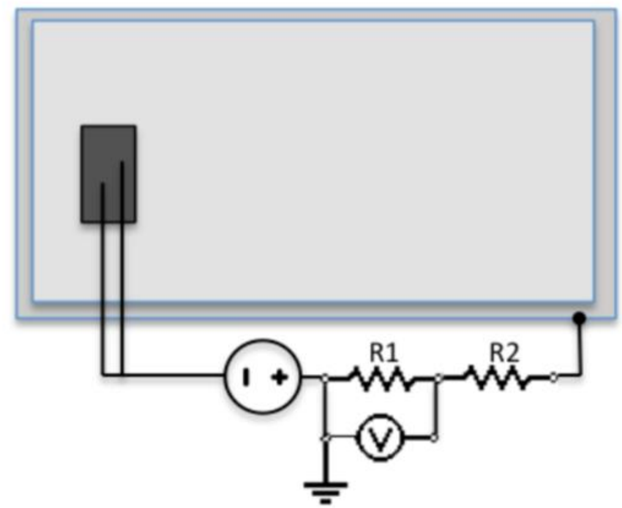
- Especially (but not limited to) p-PERC cells where performance is lifetime limited
- Occurs in thin film modules, but there is resistance to included the LeTID test for thin film modules in 61215

The procedure is followed by a regeneration process

Potential-induced degradation

From: 62804-1 into next edition of 62804

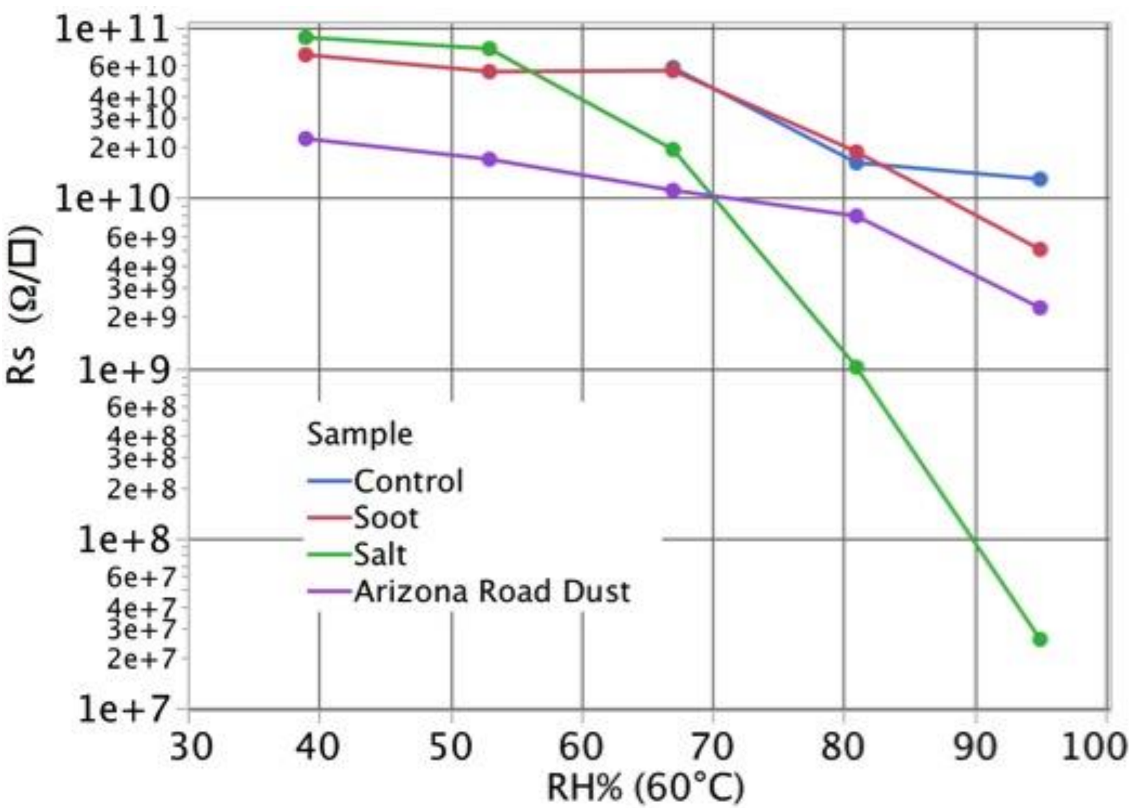




Module temperature: 85 °C ± 2 °C

- Chamber relative humidity: 85 % ± 3 % relative humidity
- Dwell: 96 h at the above stated temperature and relative humidity (not including stabilization)
- Voltage: module rated system voltage and polarities applied for the above given dwell duration and during ramp down of temperature to ambient conditions.

Sheet resistance of various soils on glass and an unsoiled control as a function of relative humidity



T=60°C Dwell time at each level: 1.25 h

<u>Arizona road dust:</u>

- Lower sheet resistance compared to the control
- humidity-independent but elevated leakage current suggest increased PID in a low-humidity environment

<u>Soot:</u>

- Did not show significant conductivity over the unsoiled control
- Different soot and other carbon-containing compounds may have differing results

<u>Sea Salt:</u>

- 3.5 order of magnitude decrease in resistance with relative humidity increase from 39% to 95%.

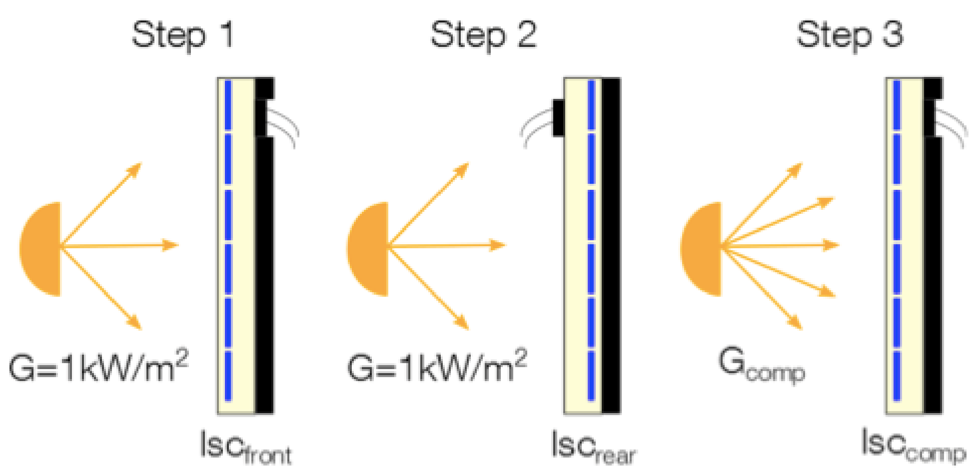
Testing for power of bifacial modules

From: developing 60904-1-2 into next edition of 62804

G_{comp} approach

Measurement principal

Overexposure based on the bifaciality



$$Isc\downarrow comp = (1+0.2\times \text{Bifaciality})\times Isc\downarrow front$$

G_{comp} : *reflectivity-compensated irradiance, when* $Isc = Isc_{comp}$

IEC 61215 MQT 11 TC 200, addition of weight

- Poor adhesion of the junction box to the module has been observed in both fielded modules and accelerated tests. Thus, in edition 2, the thermal cycling test (MQT 11) is modified to include a 5N weight hanging from the junction box.

NMOT

Removal of the nominal module operating test (NMOT), and associated test of performance at NMOT, from the 61215 series

Salt Mist

IEC 61701 ed 2 SALT MIST CORROSION TESTING OF PHOTOVOLTAIC (PV) MODULES

Dust/Sand test: T be determined

Shipping & handling

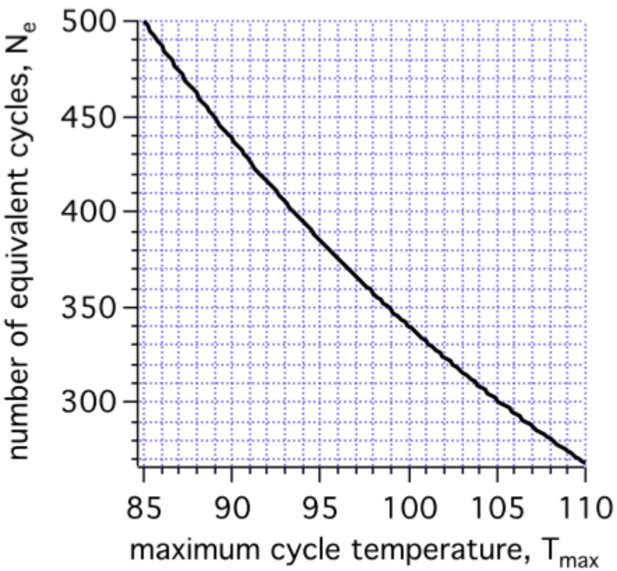
IEC 62759- 1 shipping
IEC 62759- 2 handling

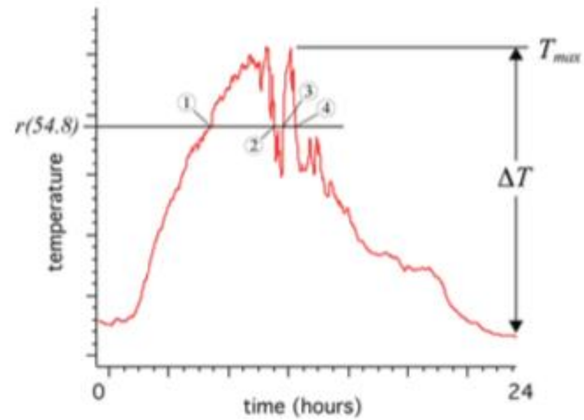
IEC CD 62892-2

TESTING OF PV MODULES TO DIFFERENTIATE PERFORMANCE IN MULTIPLE CLIMATES AND APPLICATIONS –

Part 2: Test Procedure for Thermal Cycling

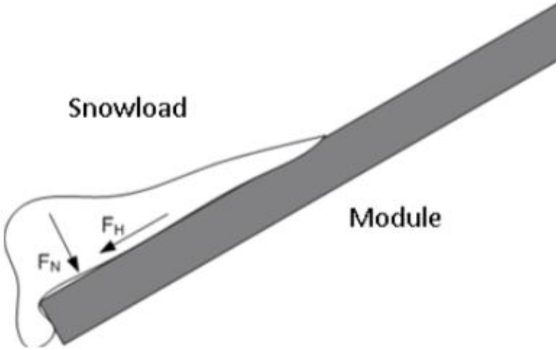
This standard is based on the ability for 95 % of the modules represented by the samples submitted for this test to pass an equivalency of 500 thermal cycles, as defined in IEC 61215-2 Section 4.11.3, with a maximum power degradation of less than 5 %.





Non-uniform snow load testing for photovoltaic (PV) modules

IEC 62938



Angel of pitch of roof α	0°< α ≤ 30°	30°< α < 60°	α ≥ 60°
μ_i	0,8	0,8x(60°- α)/30	0,0

At a test angle of 37° μ_i = 0,61 applies. (This is considered as the most critical angle for snow slides.)

3.4 Specific snow weight γ [kN/m³]

The specific snow weight is the weight per unit volume of snow. The specific snow weight γ is considered to be 3 kN/m³.

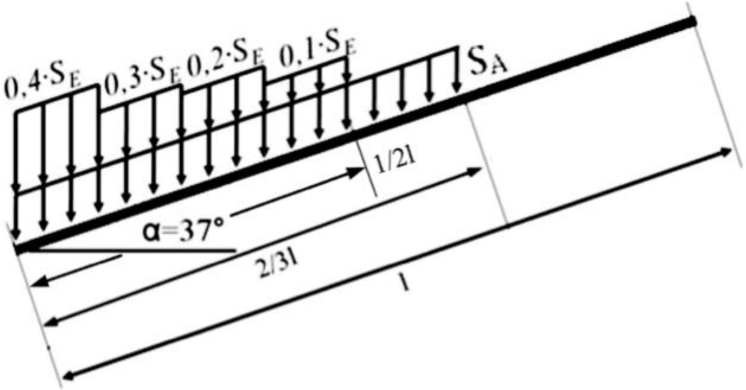


Figure 2: Distribution of load on the test specimen at inclination

IEC TS 62941

Guideline for increased confidence in PV module design qualification and type approval

IEC TS 63126: GUIDELINES FOR QUALIFYING PV MODULES, COMPONENTS AND MATERIALS FOR OPERATION AT HIGH TEMPERATURES

Standard	Test Ref	Test Name	Proposal - Level 1	Proposal - Level 2
IEC 61215	MQT 09	Hot-spot endurance test	+10°C, 60±10°C	+20°C, 70±10°C
	MQT 10	UV preconditioning	+10°C, 70±5°C	+20°C, 80±5°C
	MQT 11	Thermal cycling test	+10°C, 95±2°C	+20°C, 105±2°C
	MQT 18	Bypass diode testing	+10°C, 85±2°C	+20°C, 95±2°C
IEC 62979	N/A	Bypass diode-thermal runaway test	+5°C/+20°C, 95±2°C	+15°C/+30°C, 105±2°C
IEC 61730	5.5.2.3.3	RTI/RTE/TI	**min RTI 100°C**	**min RTI 110°C**
	N/A	Weathering exposure	XXX	XXX
	MST 21	Temperature Test	Installation/Tmax_amb	Installation/Tmax_amb
	MST 22	Hot spot endurance	See MQT 09	See MQT 09
	MST 25	Bypass diode thermal	See MQT 18	See MQT 18
	MST 37	Material creep test	N/A	110°C
	MST 51	Thermal cycle	See MQT 11	See MQT 11
	MST 54	UV test	See MQT 10	See MQT 10
	MST 56	Dry heat conditioning	N/A	110°C
IEC 62852	IEC 60512 5a	Temperature rise test	ULT post MST 21	ULT post MST 21
	IEC 60512 11i	Dry heat conditioning	CONCONNECTOR	CONCONNECTOR
	6.3.11	Change of temperature (temp cycling)	CONCONNECTOR	CONCONNECTOR
	ISO 4892-2	Weather resistance (UV exposure)	ongoing debate	ongoing debate
IEC 62790	5.3.13	Ball pressure test for enclosure (90°C)	100°C	110°
	5.3.9	Thermal cycle test	CONBOX	CONBOX
	5.3.18	Bypass diode thermal test	See MQT18	See MQT18
	5.3.15	Resistance against aging	CONBOX	CONBOX
	ISO 4892-2	Weather resistance (UV exposure)	ongoing debate	ongoing debate
	Annex B	Conformal coating requirements	CONBOX	CONBOX
IEC 62930	N/A	No changes	N/A	N/A

[62852 Connectors for DC-application in photovoltaic systems - Safety requirements and test

62790 Junction boxes for PV modules]

Temperature Level 1

Temperature Level 1 is used to categorize test modifications and applies for PV modules whose 98th-percentile temperature falls into the range greater than 70 °C but less than or equal to 80 °C.

Temperature Level 2

Temperature Level 1 is used to categorize test modifications and applies for PV modules whose 98-percentile temperature falls into the range greater than 80°C but less than or equal to 90°C.

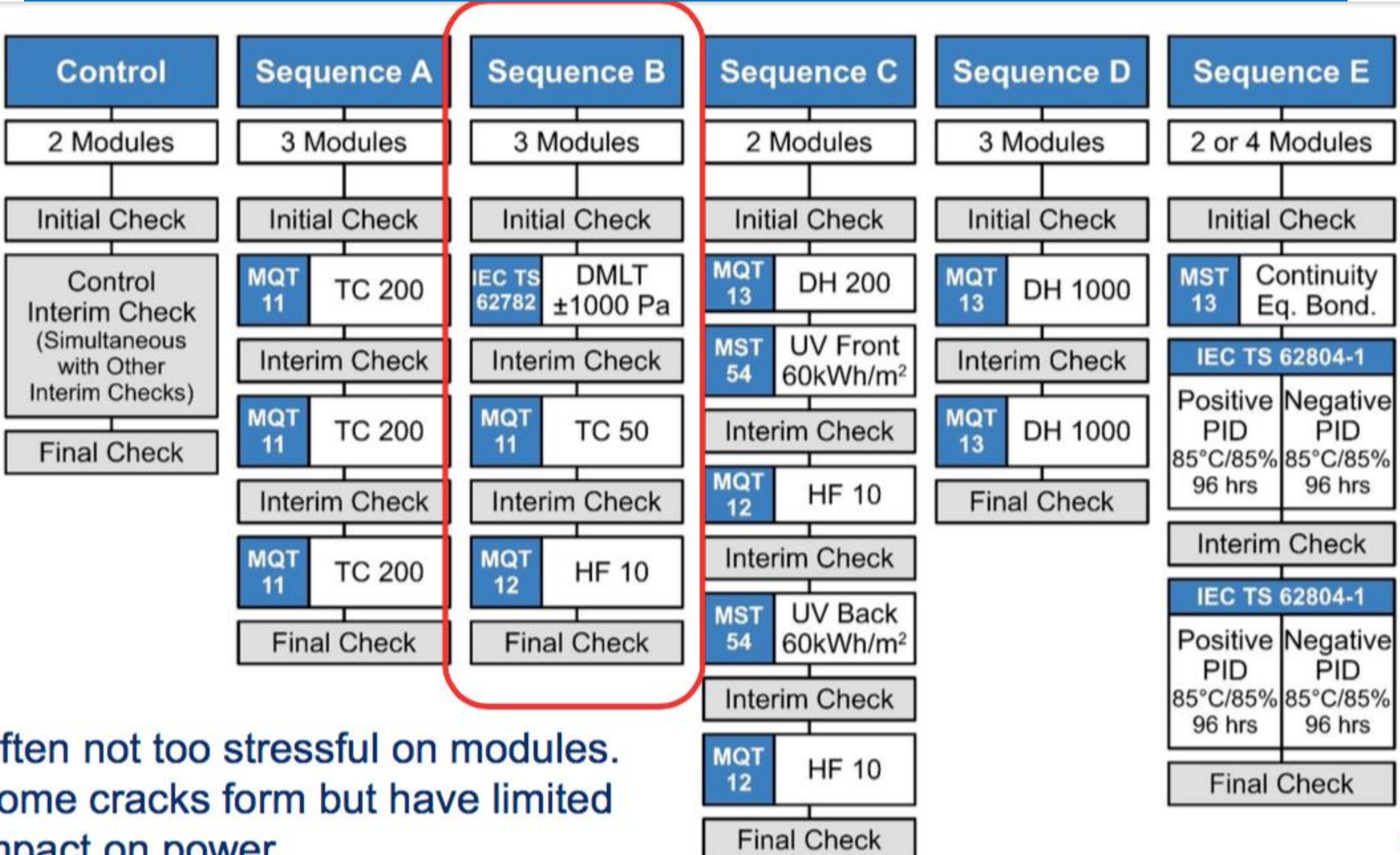
Table 8 – Service life test group C

Test Phase	Designation	IEC 60512 Test No.	Test According To	Severity or Conditions	M Des Titl
D2	Temperature rise test	5a	6.3.4	The test shall be carried out with rated current as specified by the manufacturer at an ambient temperature of 85 °C or the maximum ambient temperature specified by manufacturer, if higher;	
D3	Dry heat	11i		Test temperature: Upper limiting temperature specified for the specimen Test duration: 1 000 h	
E2	Change of temperature (temp cycling)		6.3.11	Upper temperature: +85 °C Lower temperature: −40 °C Number of test cycles: 200 During thermal cycle test the rated current shall be applied such that it is conducted through the current-carrying contacts.	Visual

Test Group	Test sequence	Major Test Items	Temp Related Requirements
B	Single	Material test	Ball pressure: 90C for enclosure, 125C for live parts support.
E	I	Thermal cycle test **Check IEC 60068-2-75 and IEC 60060-2-14**	200 cycles –40C to + 85C

Test Group	Test sequence	Major Test Items	Temp Related Test
J	V	IP test	**IP test after gasket or J-box store 240h at (100 ± 5)C, 16h Tamb, open/close 10 times.**

IEC 63290 Extended testing of PV modules



Often not too stressful on modules. Some cracks form but have limited impact on power.

Delamination

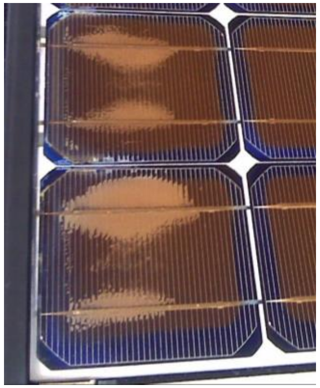
General understanding that temperature, humidity, light, and voltage potential lead to delamination

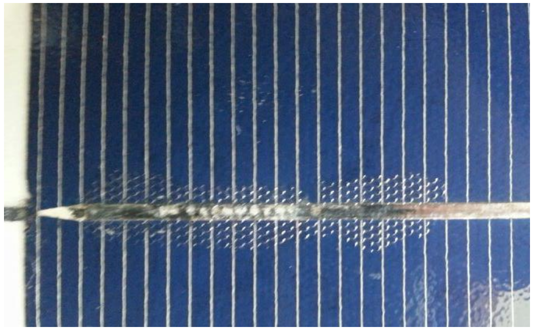
Electrochemical mechanisms of leakage-current-enhanced delamination and corrosion in Si photovoltaic modules, Solar Energy Materials and Solar Cells 188 (2018) 273–279

Potential-Induced Degradation-Delamination Mode in Crystalline Silicon Modules Presented at the 2016 Workshop on Crystalline Silicon Solar Cells and Modules: Materials and Processes Vail, Colorado August 28–31, 2016 NREL/CP-5J00-67256 https://www.nrel.gov/docs/fy18osti/67256.pdf

Microscopic Degradation Mechanisms in Silicon Photovoltaic Module under Long-Term Environmental Exposure, Japanese Journal of Applied Physics 51 (2012) 10NF07

The temperature, humidity, and voltage potential part of the equation has been put into the standard IEC 62804-1-1 (draft)





Thank you

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Publication Number

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