

Raising the bar for PV module quality and efficiency with Q CELLS and TÜV Rheinland

Presented by



Christian Taubitz
Technical Expert in the
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Department
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Business Field Manager -
PV Modules and Solar Thermal
TÜV Rheinland



Moderated by

Mark Osborne
Senior News Editor
PV Tech

QUALITY CONTROLLED PV (QCPV) – 2PfG 2715/11.19

*How Q CELLS and TÜV Rheinland aim to set new global benchmarks
in PV module quality and durability*

R&D | THA | 19.01.2021

Dr. Christian Taubitz (Staff Expert, Global Research & Development)

WHAT IS A CERTIFICATION?

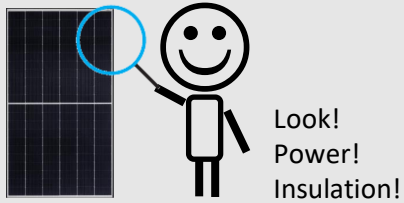
PROCESS done or supervised by an independent third party (e.g. TÜV, VDE)

Conducted in order to verify a STANDARD fulfillment

Successful certification is verified by a CERTIFICATE

Certification process

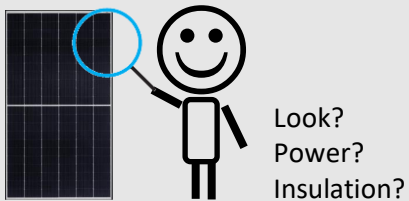
Initial module characterization



Module tests according to standard



Final module characterization



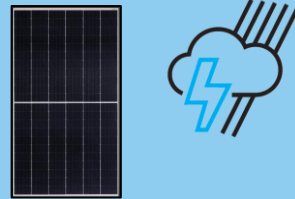
IEC Standards* for PV

***Recommendations & Regulations** defined by International Electrotechnical Commission (IEC)

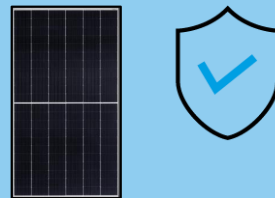
Describe:

- characterization methods e.g. performance, insulation
- test methods e.g. climate chamber, mechanical load

IEC 61215: Focus on performance tests



IEC 61730: Focus on safety tests



Certificate



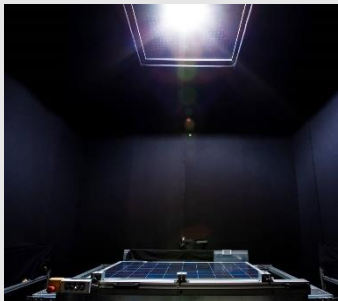
WHAT IS A STANDARD IEC CERTIFICATION ABLE TO DO




Standard IEC certification can align

IEC certification aligns power rating



→ Defines performance measurement procedure



ENGINEERED, DESIGNED AND QUALITY TESTED BY Q CELLS IN GERMANY			
Q.PEAK DUO ML-G9 405			
PERFORMANCE AT STANDARD TEST CONDITIONS*			
Nominal Power* (P _{max})	P _{max} [W]	405	
Short circuit current*	I _{sc} [A]	10.80	
Open circuit voltage*	V _{oc} [V]	45.17	
Current at maximum power	I _{mp} [A]	10.43	
Voltage at maximum power	V _{mp} [V]	38.82	
Maximum system voltage	V _{sys} [V]	1000	
Weight	M [kg / lbs]	19.5 / 43.0	
*Measurement tolerances: P _{max} ±3%, I _{sc} , V _{oc} ±0.5% at STC: 1000W/m², 25 ±2 °C, AM 1.5 according to IEC 60904-3. Data given are rated (nominal) values.			
  			

Standard IEC certification can protect

IEC certification requires basic protections



→ Mechanical load test
→ Hot Spot test



Standard IEC certification can guarantee basic performance & durability

IEC certification proves basic suitability



→ Successful certification



First year(s)



WHAT IS A STANDARD IEC CERTIFICATION NOT ABLE TO DO

Cannot verify long term reliability

Field behavior unknown



First year(s)

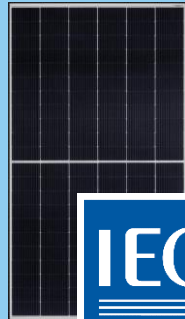


After 25 years

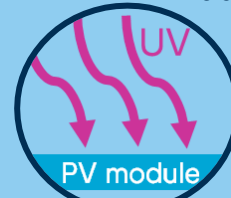


Cannot test regarding recent failure modes observed in the industry

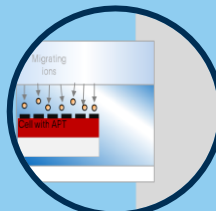
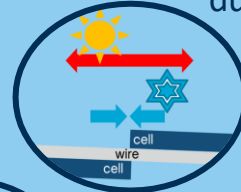
No PID, LETID, backsheet/solder-durability tests



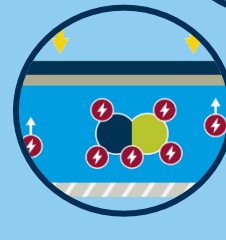
Backsheet durability



Solder durability



PID

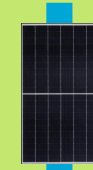


LETID



Cannot monitor production quality

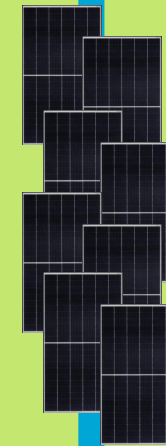
No assessment of production module



Small number of prototypes



Pass of IEC certification



Years of mass production without recheck of product quality



Quality Controlled PV – 2 PfG 2715/11.19

Quality Control System for Crystalline Silicon
Photovoltaic (PV) Module Manufacturing



Introduction TÜV Rheinland

Offering tailor-made solutions for manufacturers, EPCs and investors along the value chain globally.

More than **35** years of experience in PV.

Power plant inspections since **1990.**

More than **500** locations in **59** countries worldwide.

8,000 m² of lab testing areas

250+ PV experts worldwide.



Why Quality Controlled PV by TÜV Rheinland

Market needs

- Manufacturers wish to differentiate their products
- Investors / Insurers wish to evaluate their investments
- Pace in new technology changes need to be addressed by Quality Control System
- Appropriate testing scheme to assess long-term PV-module reliability

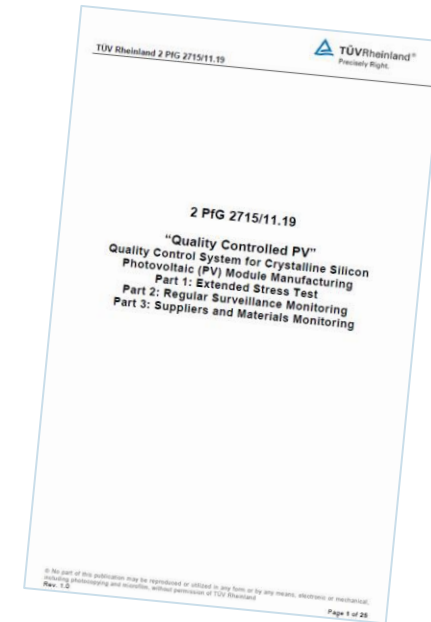
What is TÜV Rheinland going to do?

- Extended stress testing following IEC TS 63209-1 to ensure that quality surpasses standard type approval and safety qualification
- Verifying manufacturers' regular quality and surveillance measures at the production sites
- Confirming manufacturers' material and supplier-monitoring programs for all critical materials, including supplier change control

Targets and Benefits

- Risk mitigation: reveal deficiencies and detection of possible field failures with testing
- Higher quality: confidence in consistency or quality control of production with regular monitoring

QC PV, as independent testing and certification program from TÜV Rheinland, is the most progressive program on the market to continuously monitor on product quality and durability in mass production!



The keyword **"Quality Controlled PV"** confirms the certified PV modules has passed extended stress testing and undergo a regular quality surveillance monitoring.

Why Quality Controlled PV by TÜV Rheinland

Failure Systematics in PV

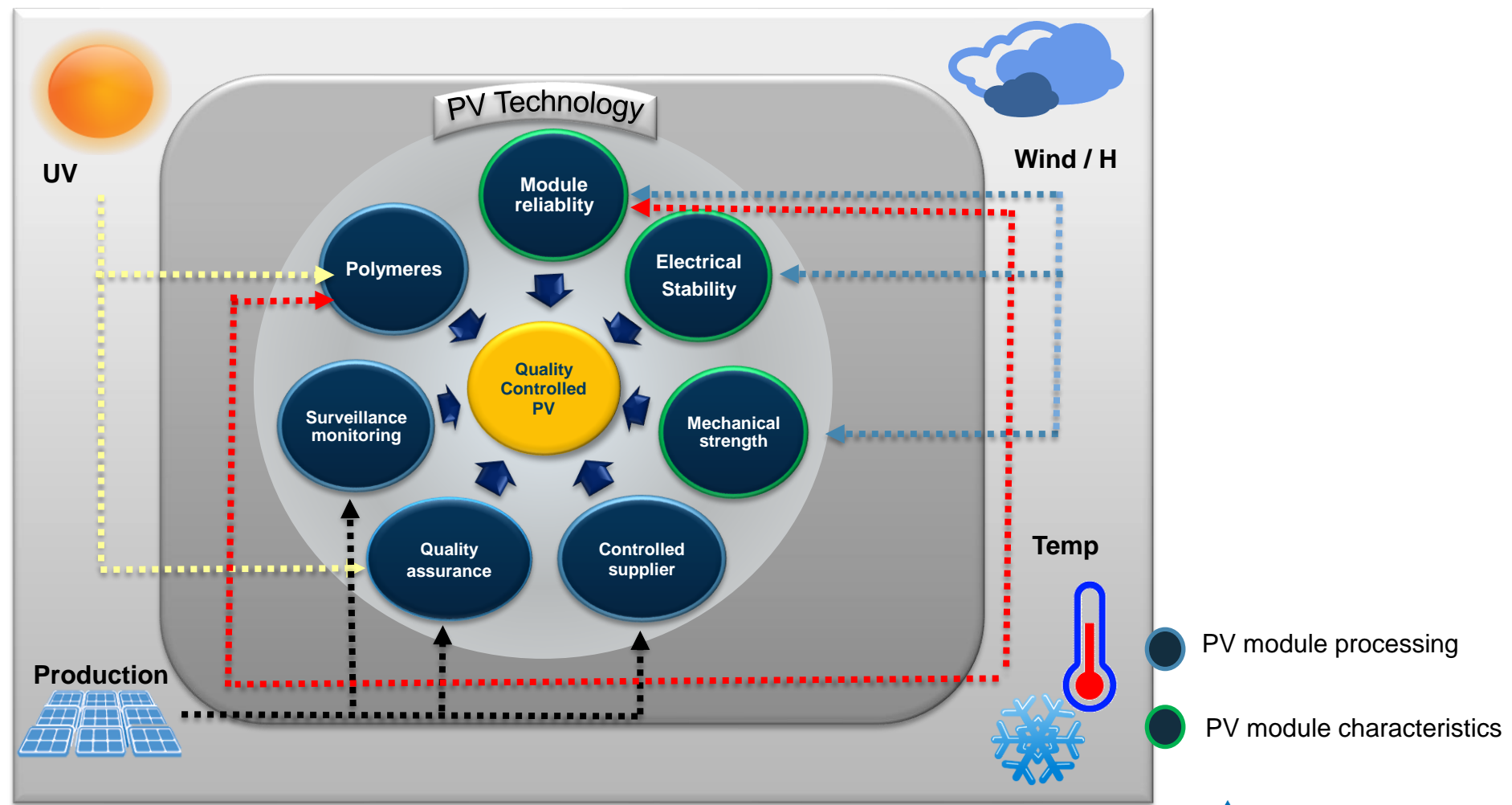
Type approval acc. to standards



- Approval and certification acc. to (inter-)national standards is the minimum criteria of type approval and safety for market access; Testing acc. to standards identifies failures of the early years life cycle only!
- Fulfilling standards for type approval and safety by certification is no evidence for a 10 year product- or 25 year performance guarantee!
- Confidence in reliability of PV Modules leads to risk minimization of mid-term- and end of lifetime failures
- Regular surveillance of production site is crucial in order to quality stability

Why Quality Controlled PV by TÜV Rheinland

Factors of influence



Q CELLS MEASURES TO ASSURE OUTSTANDING QUALITY & PERFORMANCE

Implementation of an additional test and surveillance program

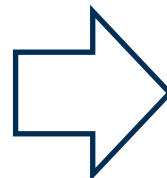


Quality
Controlled PV

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FROM NOW ON STARTING WITH
G9 SOLAR MODULES:

TÜV Rheinland Certified
Quality Controlled PV (QCPV)



UNIQUE IN THE PV INDUSTRY:

- Continuous monthly monitoring of mass production
- Continuous monitoring of material & supplier
- All conducted or supervised by TÜV representative on site

PART I: Initial Qualification Tests

Realistic and harsh tests

Up to
IEC × 3

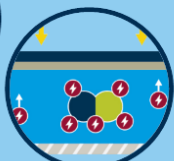
Following
IEC TS 63209

Recent failure modes are tested

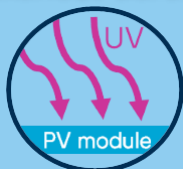
Backsheet durability



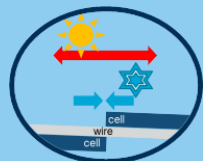
PID



LETID



PV module



Solder durability

PART II: Monitoring of production

Testing of mass production



Monthly
random sampling
&
testing

PART III: Monitoring of material & supplier

Ensuring incoming material quality

Special test methods to find &
monitor material footprint



MATERIAL-



Continuous material & supplier
monitoring
during mass production



Q CELLS MEASURES TO ASSURE OUTSTANDING QUALITY & PERFORMANCE

Implementation of an additional test and surveillance program



FROM NOW ON STARTING WITH
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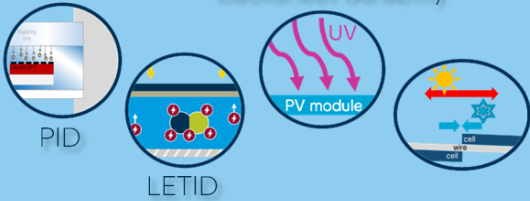
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Realistic and harsh tests

IEC × 3 Following IEC TS 63209

Recent failure modes are tested

Backsheet durability

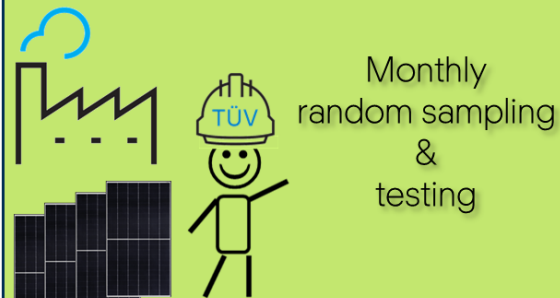


Long term
suitability of
product verified

Modules will
meet warranty
promises

PART II: Monitoring of production

Testing of mass production



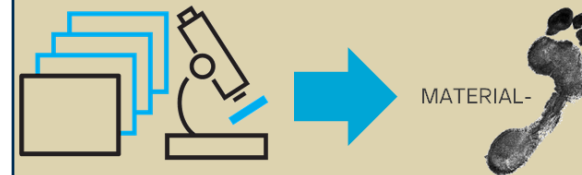
High quality of
production
verified

All supplied
modules have
same high quality

PART III: Monitoring of material & supplier

Ensuring incoming material quality

Special test methods to find &
monitor material footprint



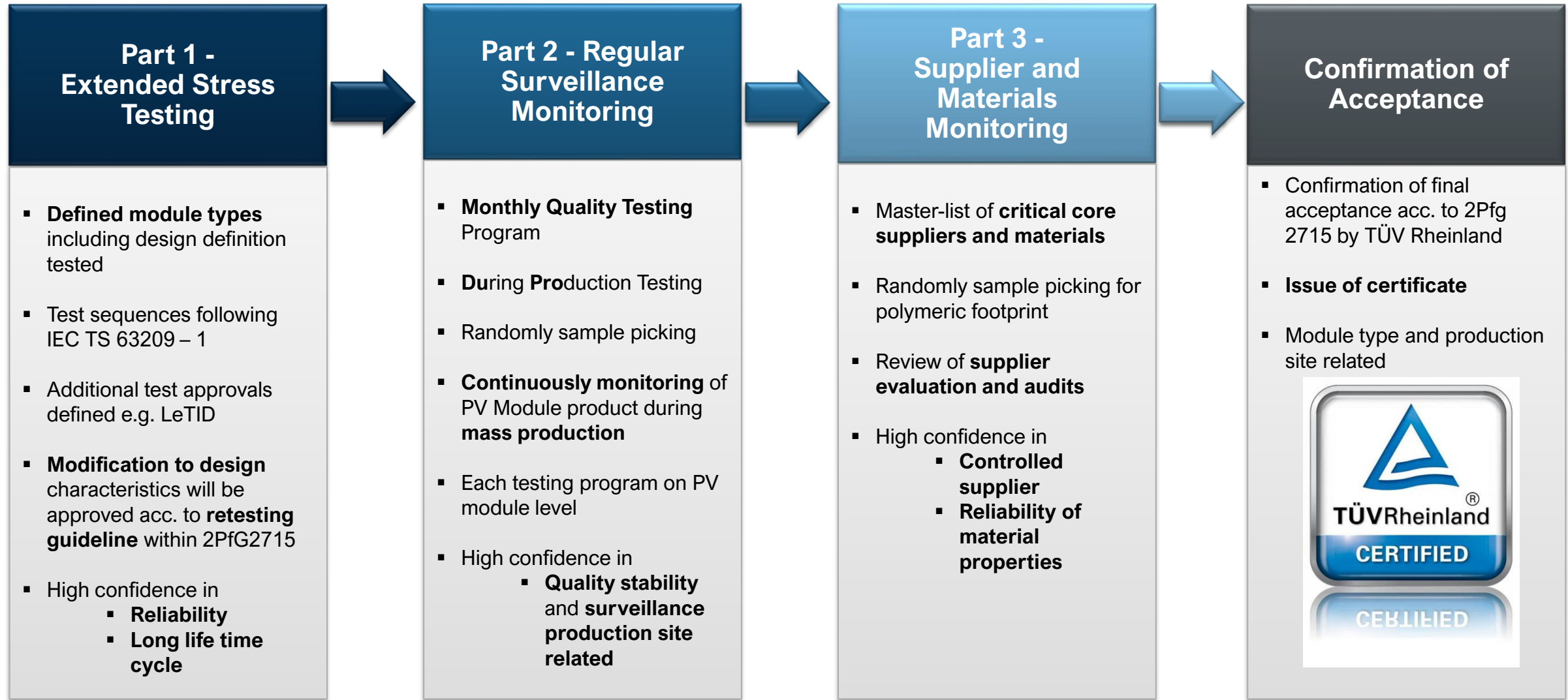
Continuous material & supplier
monitoring
during mass production

High quality of
used material
verified

No unexpected
issues in the field

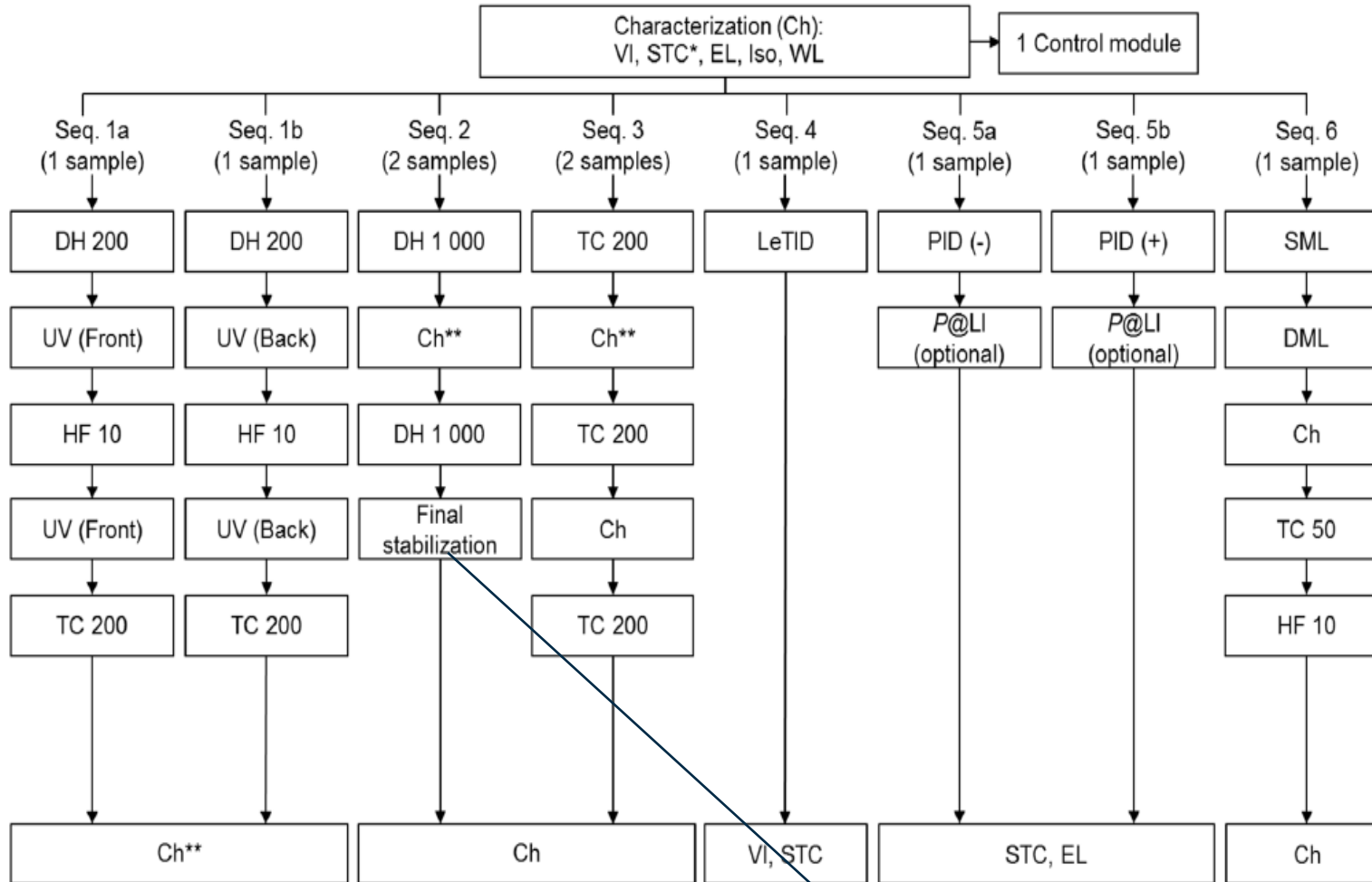


What is in 2 PfG 2715/11.19 - Quality Controlled PV



What is in 2 PfG 2715/11.19 - Quality Controlled PV

Part 1 - Extended Stress Test



* Initial stabilization required, except Seq. 4
** No requirement on performance

Proposed final stabilization: MQT 19.3 of IEC 61215-2 Ed.2 under development

- $80 \pm 5 \text{ }^{\circ}\text{C} / 48 \pm 2 \text{ hours} / \text{ISC}$
- Initial stabilization follows IEC 61215-2:2016.
- Other stabilization techniques can be used after validation.

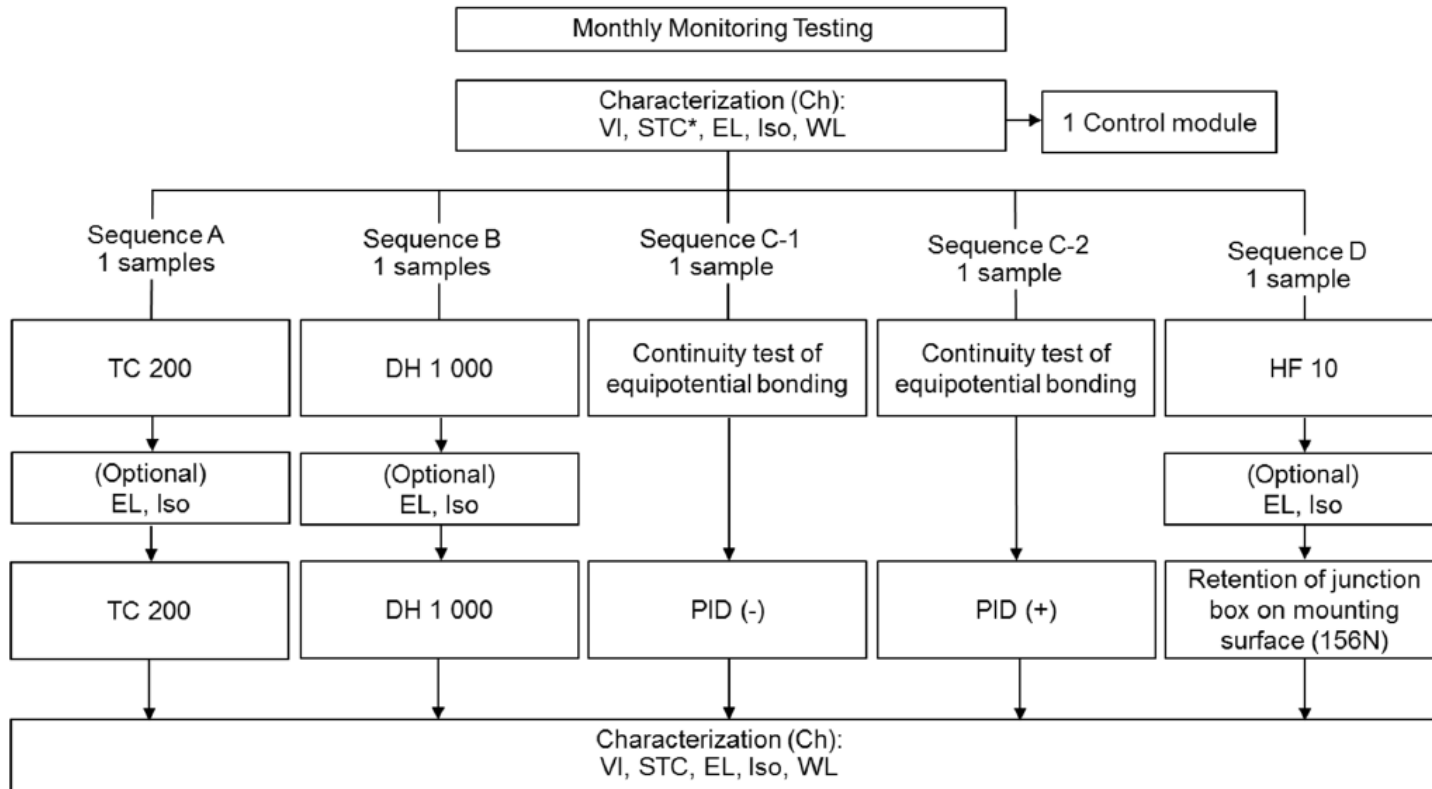
- Test procedure based on draft status of **IEC TS 63209-1**
Extended-stress testing of photovoltaic modules for risk analysis
- Eleven samples are necessary as the minimum requirements for testing; **it is allowed to provide more samples to increase confidence in test results**
- LeTID: following 2 PfG 2689/04.19
 - $2 \times (I_{SC} - I_{MPP}) / 75\text{ °C} / 300\text{ hours (max.)}$
- PID: following method 1-B or 1-C of 2 PfG 2387/01.18
 - 85 °C/ 85% RH/ 96 hours (chamber)
 - 25 °C/ < 60% RH/ 168 hours (dry/Al-foil)
- SML: 2400 Pa for tensile and pressure regardless of the designed load specified; DML: following IEC 62782 (1 000 Pa x 1 000 times)

Pass criteria

- No requirement on performance for Seq. 1a and 1b
- Less than 5% after DH 2 000
- Less than 5% after TC 400; 10% after TC 600
- Less than 5% after LeTID and PID
- Less than 5% after DML; 10% after HF 10 (Seq. 6)
- VI, Iso, WL following IEC 61215-2

What is in 2 PfG 2715/11.19 - Quality Controlled PV

Part 2 - Regular Surveillance Monitoring - *Monthly Quality Testing Program*



* Initial stabilization required

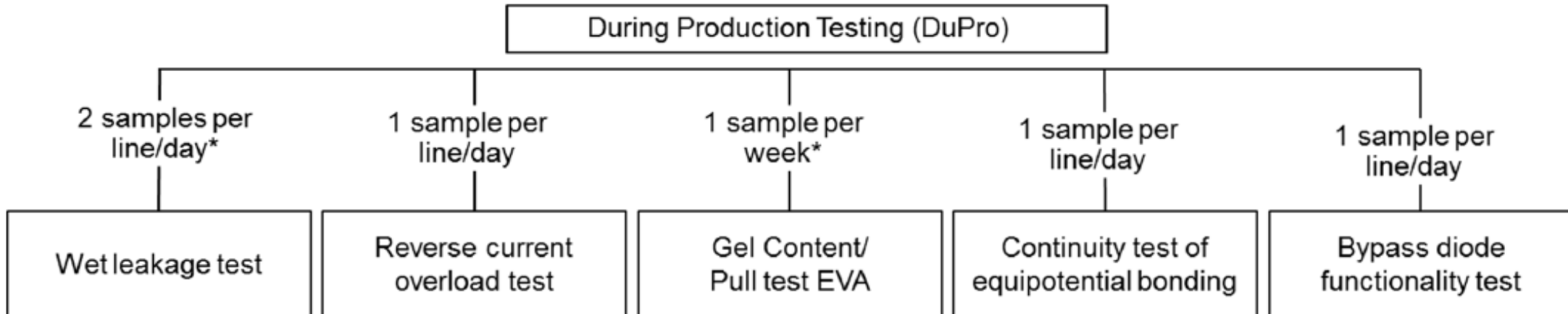
- Monthly sample picking at each production site from out of Quality Controlled PV certified module types
- The lot size of sample selection = No. of required test samples x factor 10 (minimum)
- Random selection of required test samples from this lot by TÜV Rheinland staff
- Selection of each Quality Controlled PV certified module type minimum every three years

Pass criteria

- Maximum power output drop less than 5% after testing
- VI, Iso, WL following IEC 61215-2
- Monthly monitoring and review of test protocols by TÜV Rheinland

What is in 2 PfG 2715/11.19 - Quality Controlled PV

Part 2 - Regular Surveillance Monitoring - *During Production Testing*



* In case of multiple laminators per line, a daily change of laminators is required.

- Daily/weekly sample picking at each production site out of Quality Controlled PV certified module types
- Requirements acc. to IEC 61215-2 and IEC 61730-2 after testing
- Selection of each Quality Controlled PV certified module type minimum every three years
- Monthly monitoring and review of test protocols by TÜV Rheinland staff

What is in 2 PfG 2715/11.19 - Quality Controlled PV

Part 3 - Suppliers and Materials Monitoring

Master List of Suppliers

- Definition of a master list of suppliers including supplier evaluation (material risk assessment)
- Confirmation letters of all CORE materials from suppliers are required

Core materials are rated as critical or major according to the material risk assessment

Polymeric Footprint

- Material analysis or identification measures, e.g. GC MS (Gas chromatography with mass spectrometry) / DSC (differential scanning calorimetry) or other microsection analysis methods
- ONE test sample from a minimum of TWO suppliers per month

Regular Supplier Audit

- minimum ONE supplier audit per year for core materials
- supplier to be audited shall be changed every year

PART I: INITIAL QUALIFICATION TESTS



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LEARNING PROGRAM
Extensions & Adaptions
according to industry
requirements & observations
possible

DAMP HEAT [DH]

Tested: 2000 hours (2 × IEC)



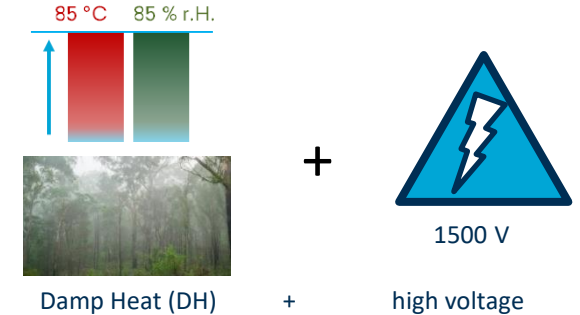
THERMAL CYCLING [TC]

Tested : 600 cycles (3 × IEC)



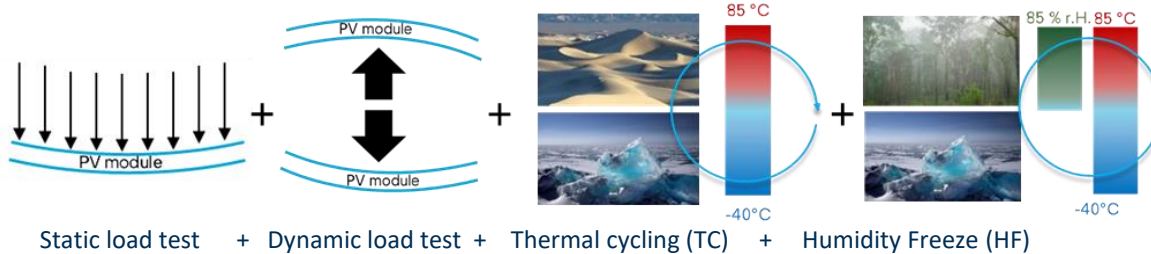
POTENTIAL INDUCED DEGRADATION [PID]

Tested: 85 % rel. humidity at 85 °C
(IEC TS 62804 = 60 °C)



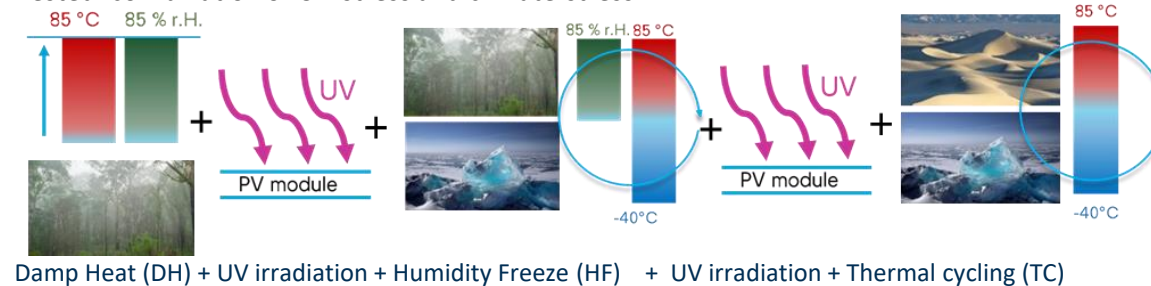
MECHANICAL LOAD TEST SEQUENCE

Tested: combination of static & dynamic load stress with climate-stress



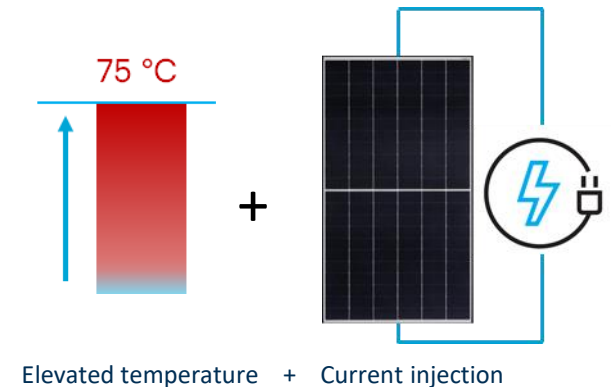
UV-TEST SEQUENCE [Backsheet resistance test]

Tested: combination of UV-stress and climate-stress



LIGHT and ELEVATED TEMPERATURE INDUCED DEGRADATION (LETID)

Tested: 300 hours (TÜV RH standard 2PfG 2689/04.19)

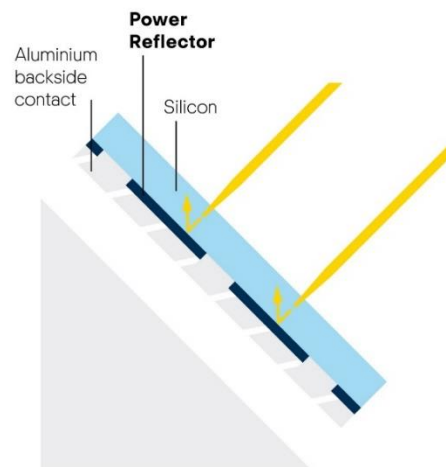


INNOVATION MEETS TRADITION

SOLAR CELLS



- 12+ years of R&D
- Commercialized 7+ years ago
- Over 4 billion Q.ANTUM cells
- More than 23 GW of Q.ANTUM solar modules



Q.ANTUM solar cells



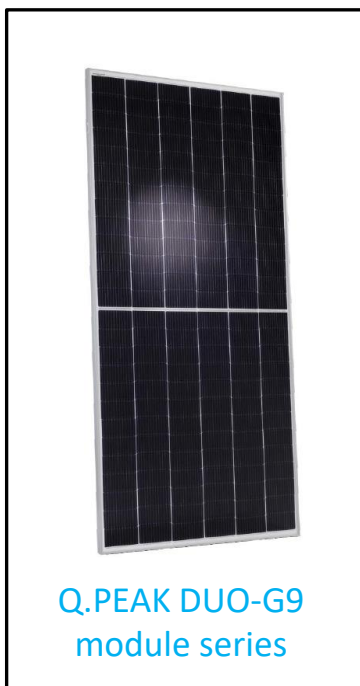
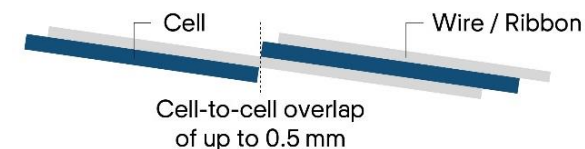
MODULE TECHNOLOGY



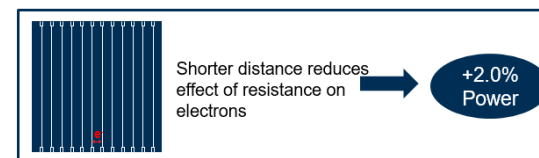
- 7 years of R&D
- More than 7 GW of Q.ANTUM DUO modules produced
- Won Intersolar PV Award 2018
- PVEL Top Performer 2019/2020 for DUO



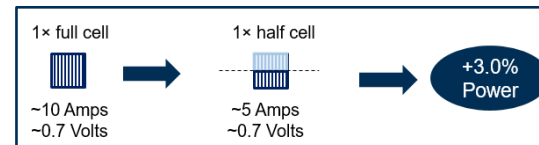
ZERO-GAP TECHNOLOGY



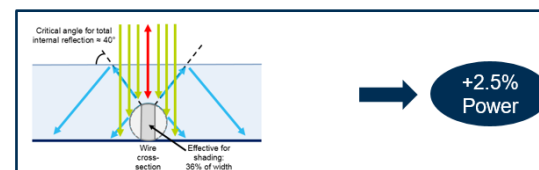
1)
12 Busbars



2)
Half-cells



3)
Round wires

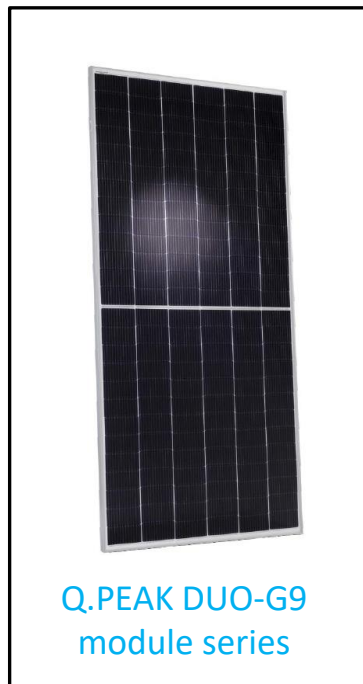


PART I: TESTING OF NEW Q.PEAK DUO-G9



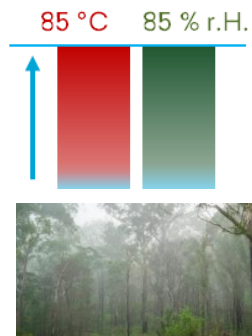
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DAMP HEAT [DH]

Tested: 2000 hours (2 × IEC)



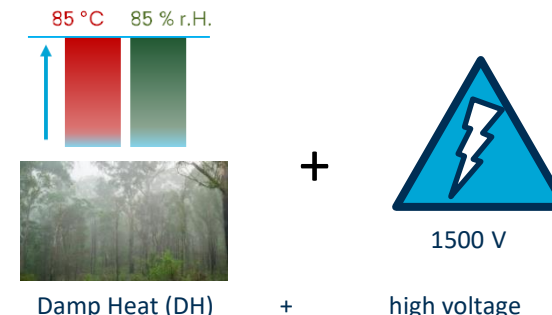
THERMAL CYCLING [TC]

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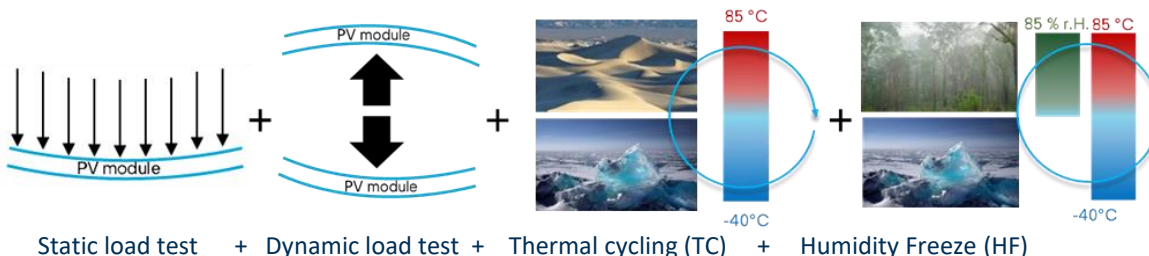
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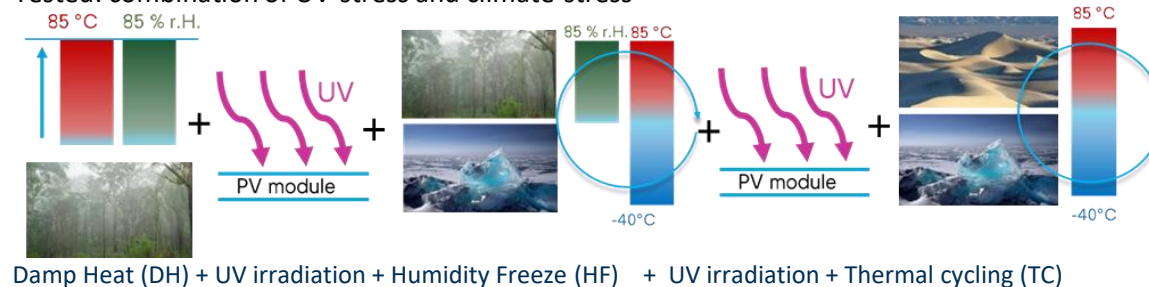
MECHANICAL LOAD TEST SEQUENCE

Tested: combination of static & dynamic load stress with climate-stress



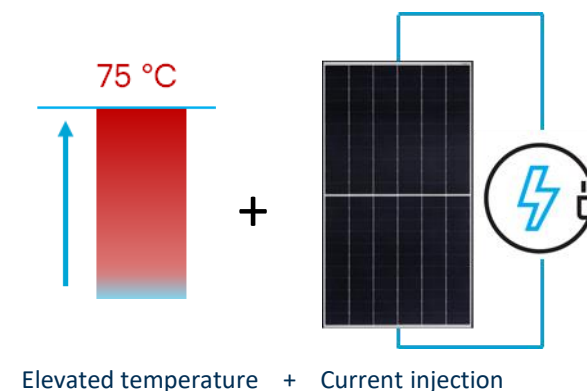
UV-TEST SEQUENCE [Backsheet resistance test]

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LIGHT and ELEVATED TEMPERATURE INDUCED DEGRADATION (LETID)

Tested: 300 hours (TÜV RH standard 2PfG 2689/04.19)

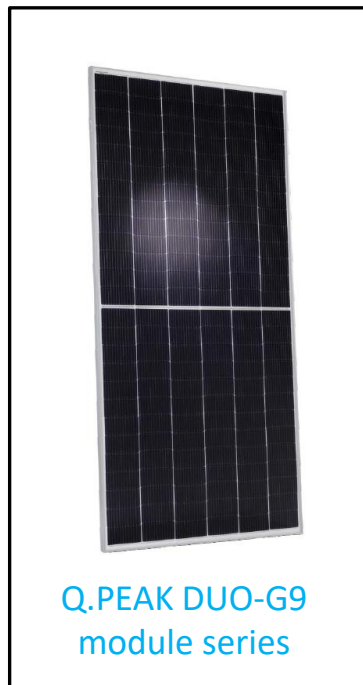


PART I: TESTING OF NEW Q.PEAK DUO-G9 – WITH OUTSTANDING RESULTS



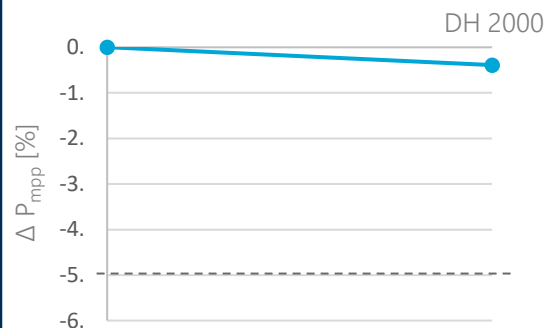
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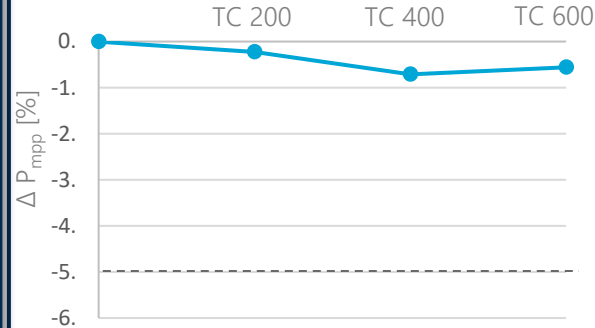
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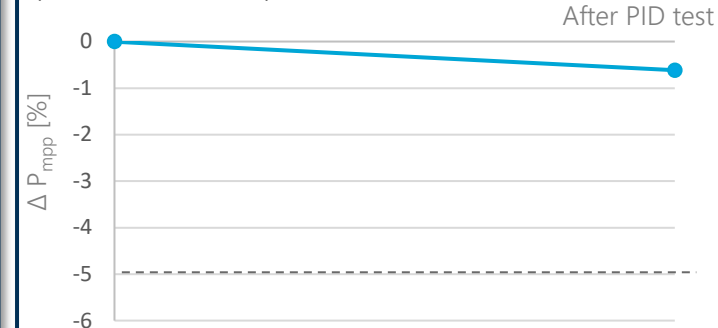
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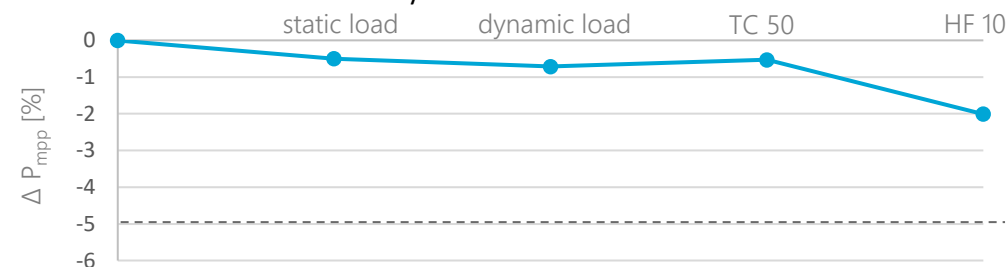
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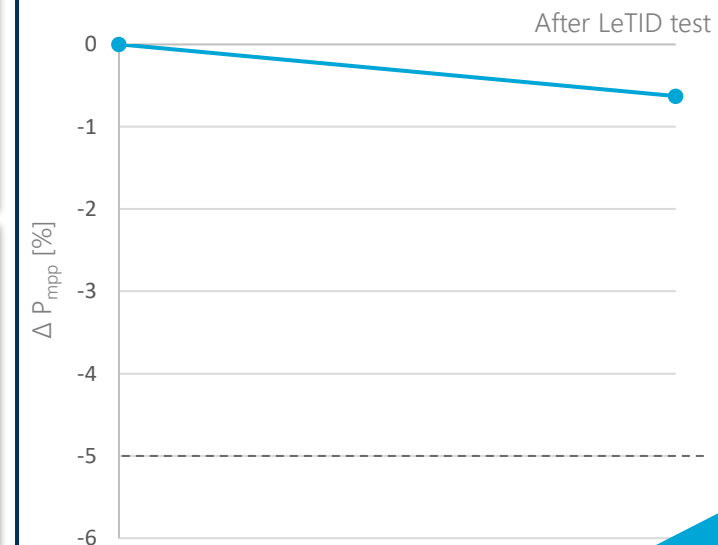
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LIGHT and ELEVATED TEMPERATURE INDUCED DEGRADATION (LETID)

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UV-TEST SEQUENCE [Backsheet resistance test]

Tested: combination of UV-stress and climate-stress

Visual inspection

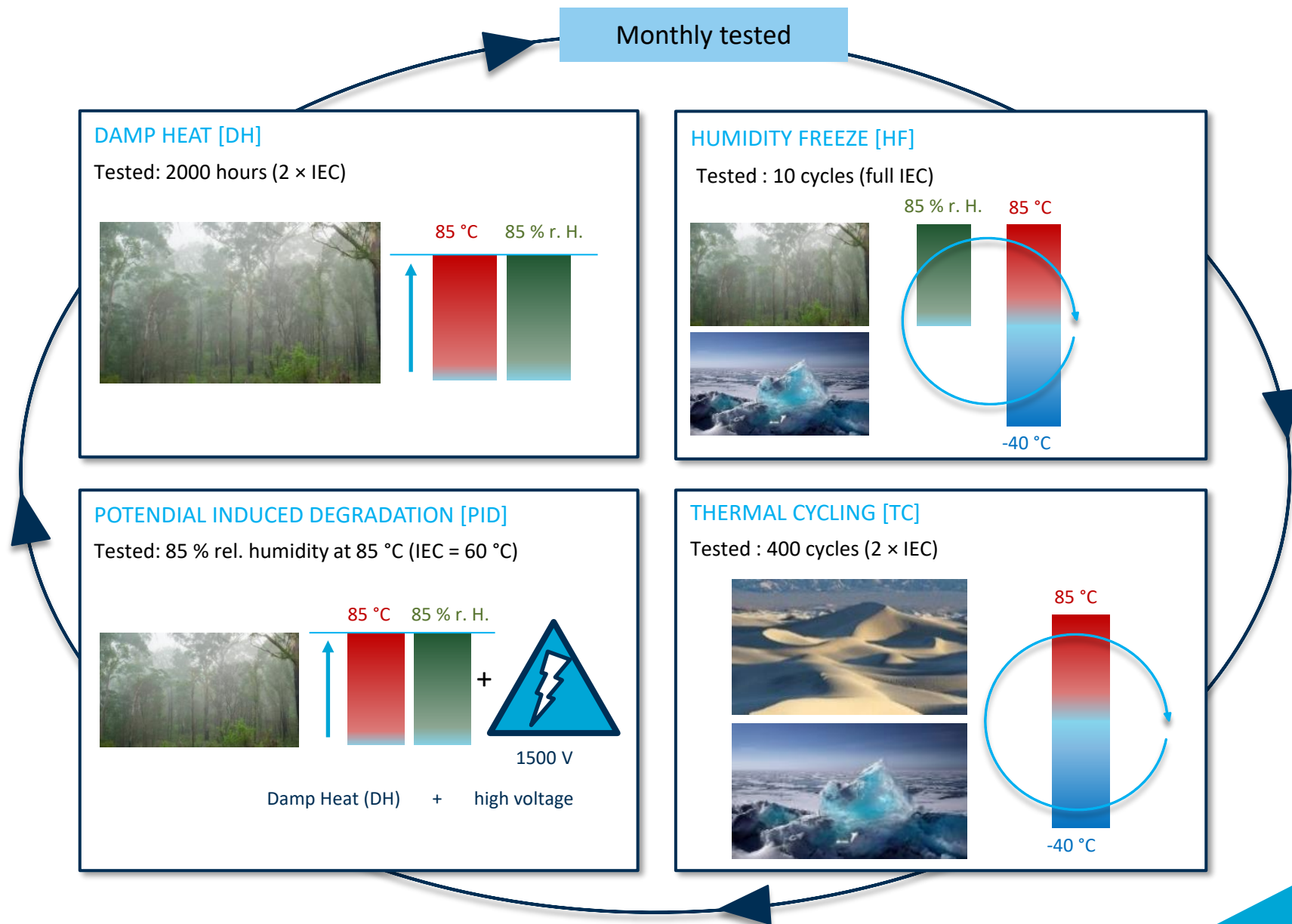
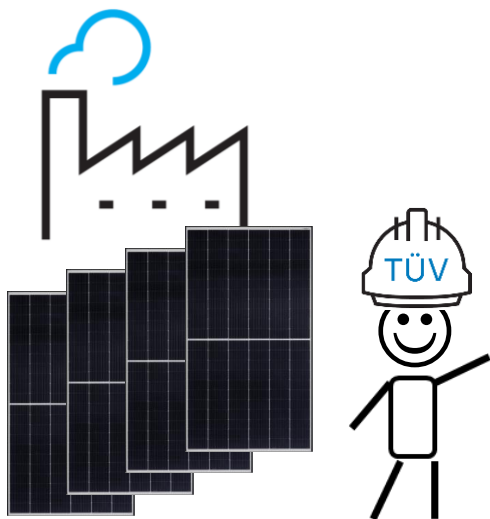


Insulation test



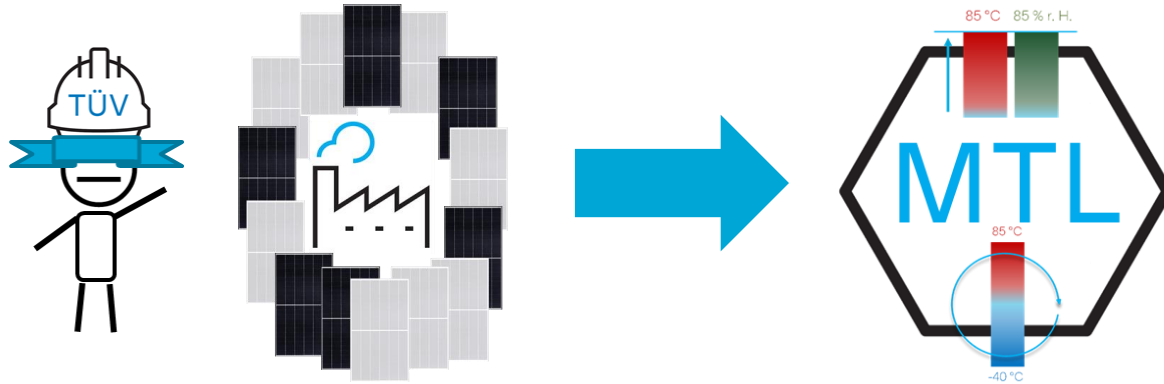
Wet leakage test



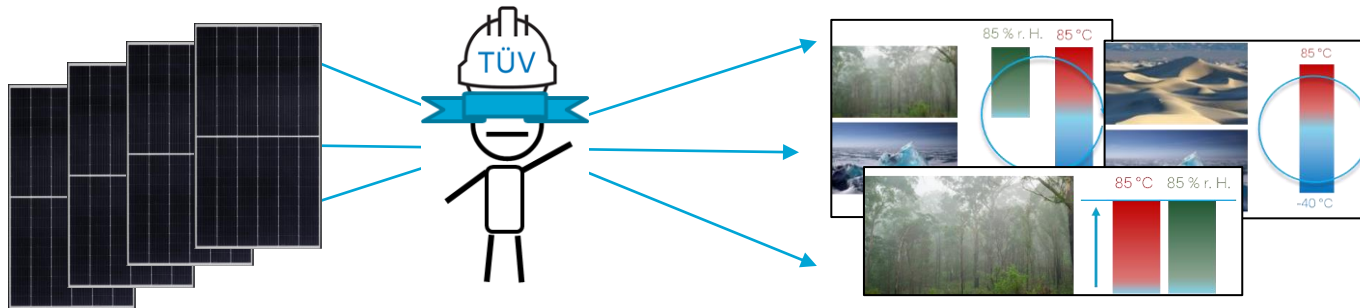


Q CELLS monthly procedure:

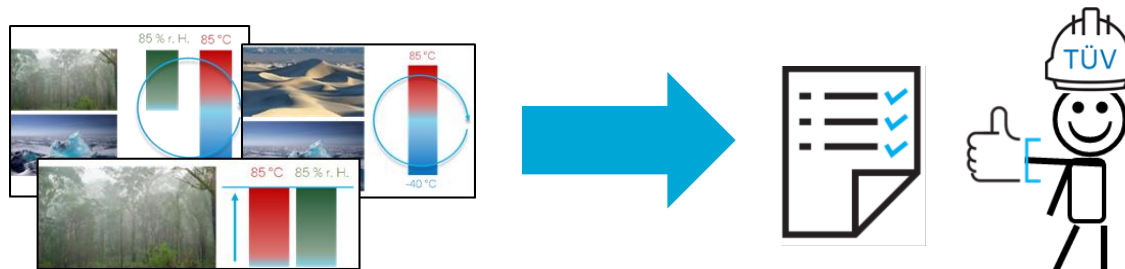
1. Random sampling at every production site by TÜV Rheinland(RH) representative. These are sent to Q CELLS certified Module Test Lines(MTL)

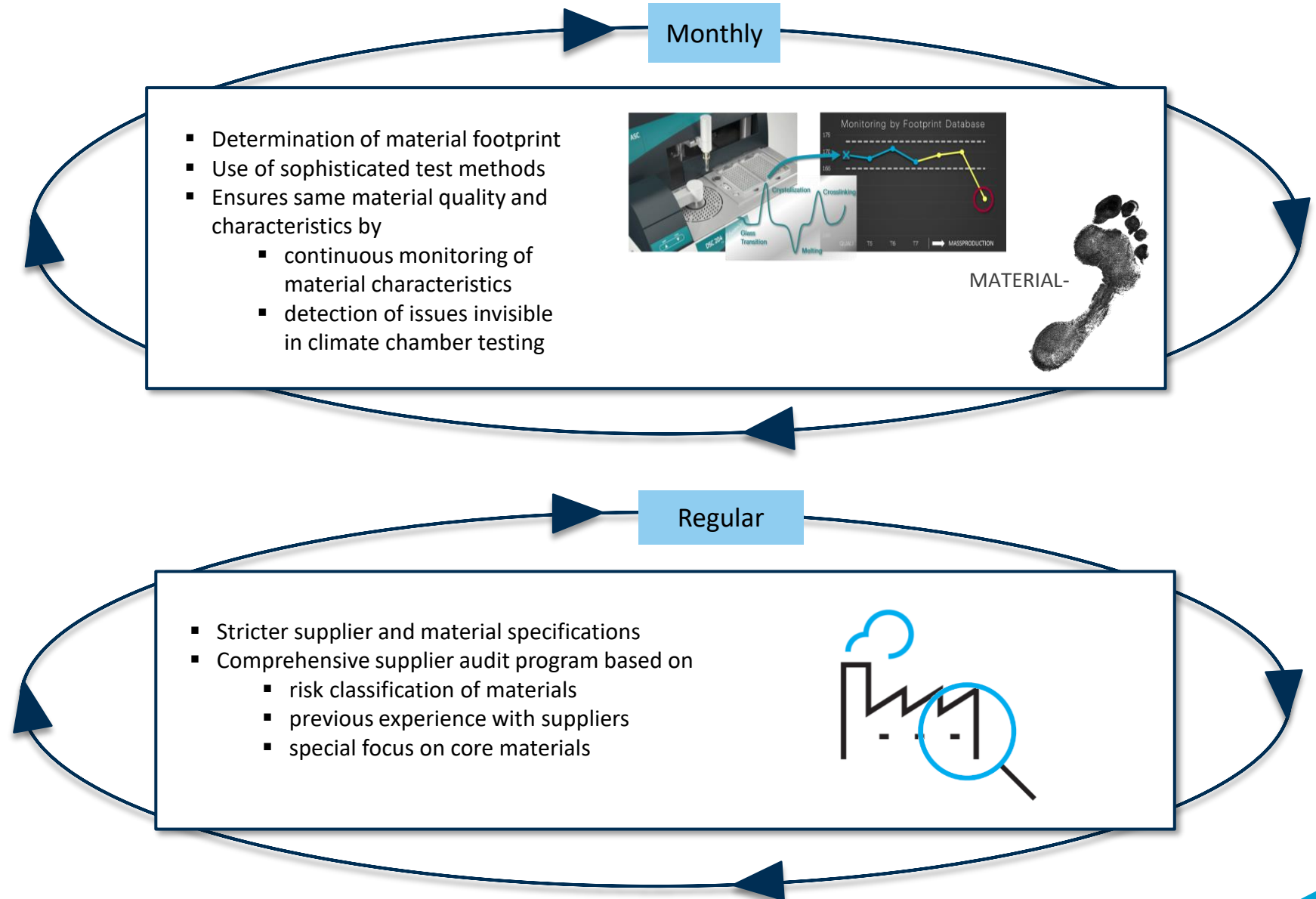
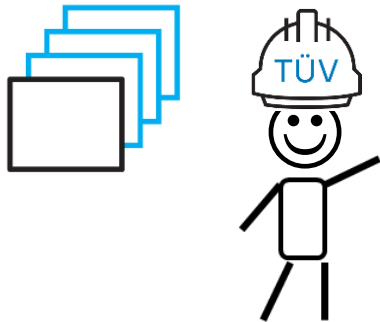


2. Before test start, the TÜV RH representative randomly assigns each module to one of the monitoring test sequences



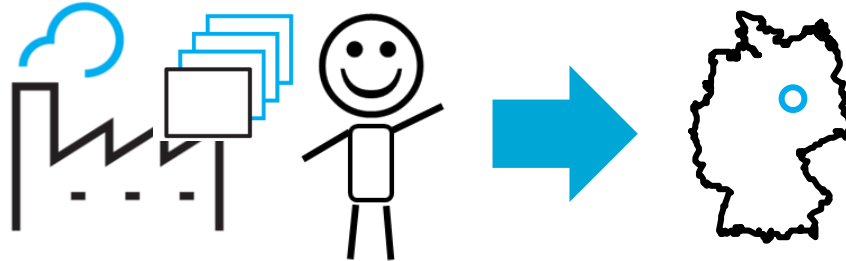
3. The tests are done at the MTL, a standardized test report is created and TÜV RH checks and confirms the report



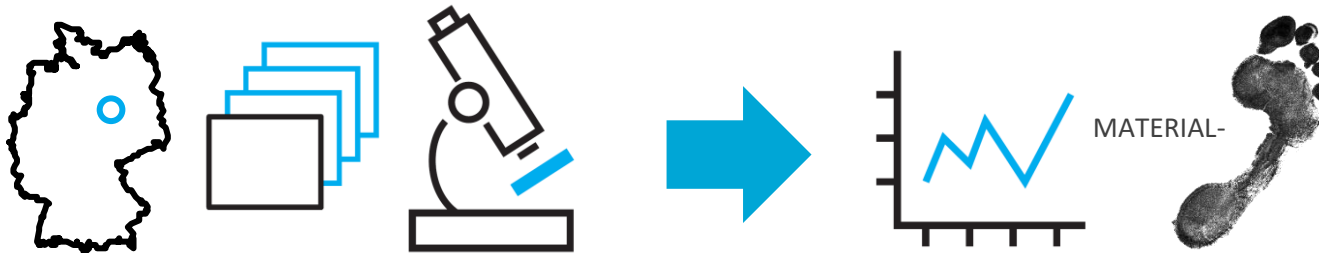


Q CELLS monitoring procedure for backsheet material:

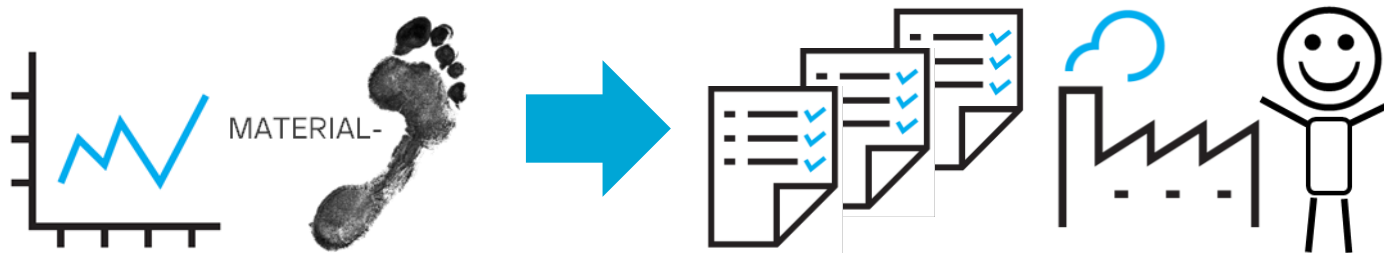
1. Production site prepares samples monthly from current production lot and sends them to Thalheim (Germany) for testing



2. Laboratory in Thalheim uses Differential scanning calorimetry (DSC) for footprint characterization



3. Results are uploaded in material footprint database and shared with local production sites



Confirmation of Acceptance

Requirements for Certification

- Test samples meet all criteria of each individual test in Part 1, 2, and 3
- A CDF (Constructional Data Form) is necessary for verification
- Requirements for Monitoring, Review of test protocols and Assessments satisfied
- IEC 61730 TÜV Rheinland safety certification covering yearly factory inspection

In case of failures

- A failure analysis report and a corrective action plan are required
- repetition of test sequence with minimum 2 samples per sequence
- Both sample shall pass the retest



Quality Controlled PV
2 PfG 2715/11.19

Quality Control System for
Crystalline Silicon Photovoltaic
(PV) Module Manufacturing

Confirmation of Acceptance

TÜV Rheinland Test Mark and Keyword!



Quality
Controlled PV



www.tuv.com
ID 1111232615

Hanwha Q Cells *First Mover* – certificate!



- ID is related to individual module type (e.g. Q.PEAK DUO BLK ML-G9+) on www.certipedia.com
- Keyword note can be consulted on Certipedia:

Quality Controlled PV

TÜV Rheinland has tested this PV module in order to ascertain that it is of better than average quality.

TÜV Rheinland has defined a catalogue of tests, which establishes additional qualities going beyond standard type approval and safety qualification.

The test catalogue is based on internationally applicable standards or common standards within the industry and exceeds these requirements.

TÜV Rheinland has introduced three specific requirements:

1. We perform an extended stress test program based on IEC 63209 for high confidence in the reliability and long lifetime of the PV module.
2. We control how the manufacturer conducts their regular quality and surveillance measures. These are performed on samples taken at random from the running production every month.
3. We verify the manufacturer's material and supplier-monitoring program for all critical components with special focus on reliability and material properties as well as supplier change control.

The PV module and its performance specifications have been checked against these criteria.

The use of the keyword "Quality Controlled PV" confirms that the PV module undergoes a regular quality surveillance monitoring program and has passed extended stress testing.

Summary

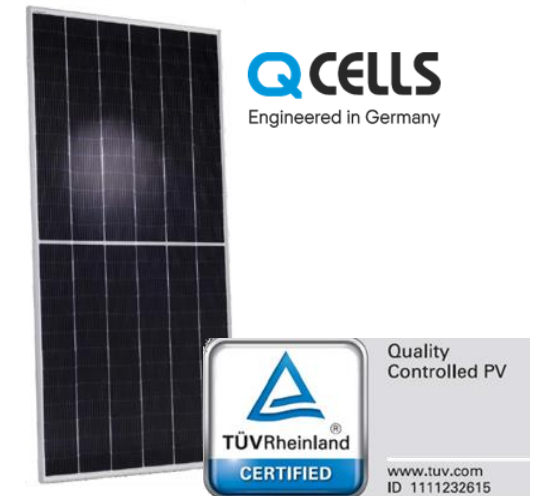
Quality Controlled PV - 2 PfG 2715/11.19

- Quality Controlled PV standard for c-Si Photovoltaic Module Manufacturer is a high-level USP on their Quality Control System
- High manufacturer's efforts in implementing QC PV leads to increased confidence in reliability and risk minimization of PV Modules
- Driven by the market to differentiate their products for manufacturers and to evaluate their investments for investors, this test specification was developed based on IEC TS 63209-1 focused for reliability testing beyond IEC 61215 and IEC 61730
- Quality stability is crucially given by regular surveillance monitoring of the production site in this program
- 2 PfG 2715 need to be performed through three levels Part1, 2 & 3 traceable per module type & design
- Quality Controlled PV is market recognized already – see CEC Australia:

	Items to check	OK
A	VDE Quality Tested or TUV Rheinland Quality Controlled PV (QCPV)	
1	Check validity of VDE QT or QCPV certificate on certifier website	
2	Check certifier is also the certifier for main 61215/61730 listing	
3	Company names and factories match	
4	Model numbers match	
5	Expiry date is valid. Note QT Certificate is re-issued yearly but does not affect 3yr CEC listing	
G	Light and elevated Temperature Induced Degradation (LeTID)	
1	Check the certificate on the certifier website (may be to Certifier standard eg TUV RH 2PfG 2689 04.19)	

CONCLUSION

- Standard IEC certification
 - is able to align methods and guarantee basic suitability
 - is not able to assess PV module long term reliability as well as quality of mass production
- Quality Controlled PV (QCPV) is the only certification in the entire industry to
 - include most extensive and stringent testing scheme available to date
 - involve independent and random onsite testing of running mass production
 - conduct regular material testing by material footprint analysis and monitoring
 - be dynamically updated in the future according to the requirements in the industry
- Q CELLS
 - is the first mover in the Quality Controlled PV program
 - had the unique opportunity to bring in its own experience
 - Q.PEAK DUO-G9 series is the first product passing QCPV with outstanding results
 - will continue to test & monitor modules and materials according to QCPV and beyond that



Q.PEAK DUO-G9
module series

THANK YOU FOR LISTENING!

Q CELLS AND TÜV RHEINLAND

