New Structure of PV Module Type Approval and Safety Qualification Standards

TÜV Rheinland Workshop "Update of IEC standards for PV modules„
Kuala Lumpur, Malaysia, 21st March 2017

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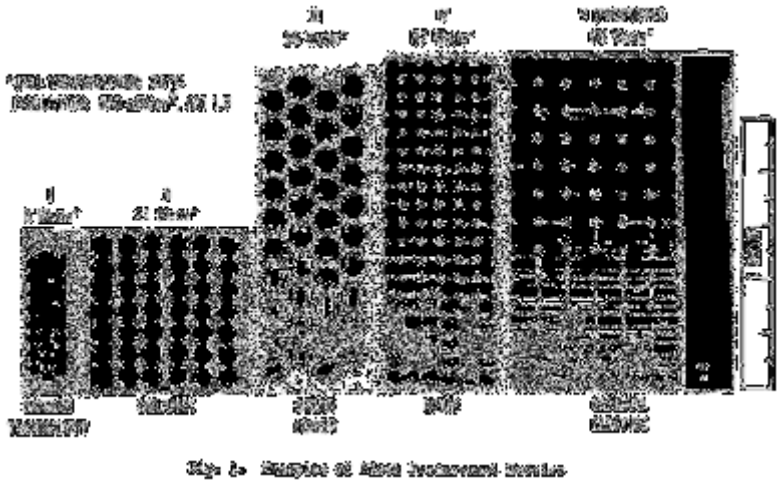
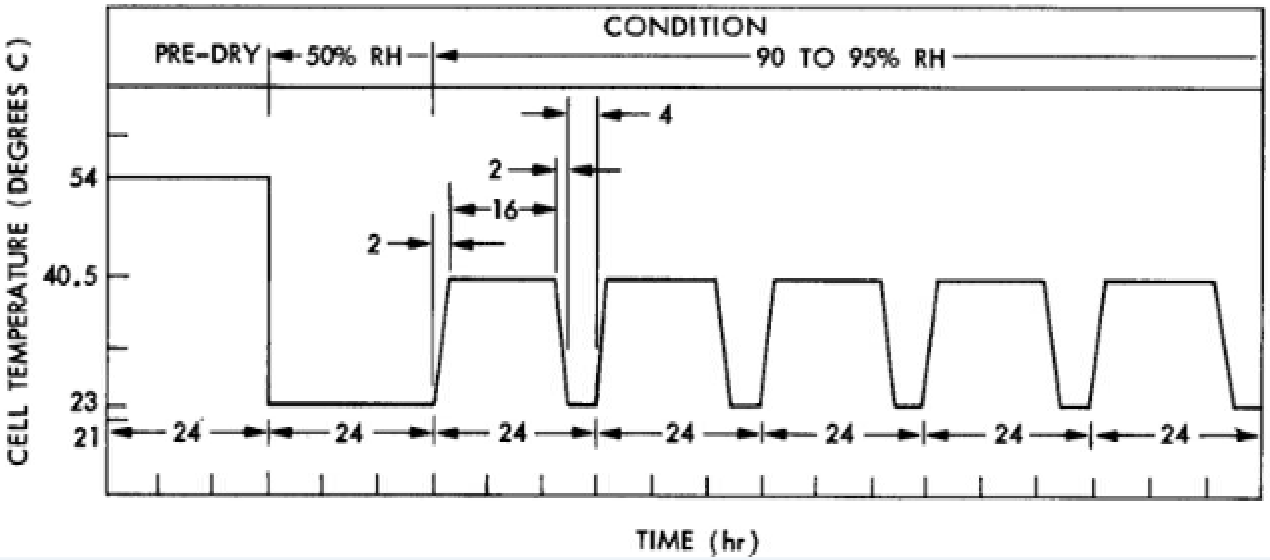
Content

Recent modifications of IEC guidelines: History

- 1975-1981: JPL ‘Block Buys’ I-V (c-Si)
  - Based on NASA tests for space applications
  - Temperature cycles (-40°C to +90°C)
  - Mechanical load, hail and isolation test intro-duced in Block V
  - Outdoor exposure mainly in the US deserts
  - Block VI cancelled due to budget cuts in Reagan administration

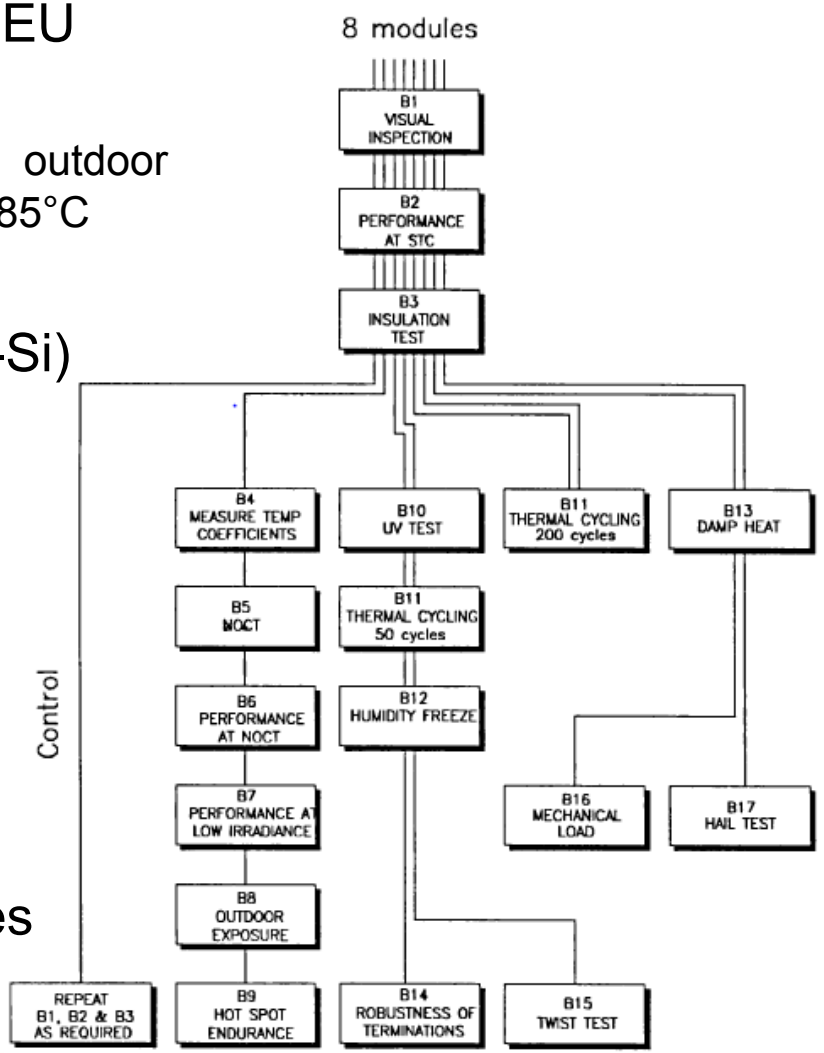




Images taken from “Experience in Design and Test of Terrestrial Solar-Cell Modules”; Smokler and Runkle, Texas, 1982

Recent modifications of IEC guidelines: History

- 1981-1991: ESTI (European Solar Test Installation, Italy) – EU Specification 501 to 503
  - Based on JPL Block V additional with UV and outdoor exposure; maximum temperature reduced to 85°C
  - EU 503 was the basis for IEC (6)1215
- 1990: SERI IQT modifications for TF (a-Si)
  - SERI: Solar Energy Research Initiative
  - Wet leakage current test
  - Bypass diode test
  - Scratch test (ANSI/UL 1703)
  - Ground continuity test (ANSI/UL 1703)
- 1993: IEC (6)1215 Ed. 1 (c-Si)
  - Combination of all available test methods
- 1995-2000: IEEE 1262 – all technologies
  - Combination of IQT and IEC (6)1215



Recent modifications of IEC guidelines: History

- 1996: IEC (6)1646 Ed. 1 (TF – a-Si)
  - Based on IEEE 1262 plus light-soaking and annealing
- 1996: TÜV Spec TZE/2.572.09
  - Safety class II Test on Photovoltaic (PV) Modules
- 2004: IEC 61730 Ed. 1 (c-Si & TF)
  - Photovoltaic (PV) module safety qualification
  - Application class A, safety class II
  - safe electrical and mechanical operation
- 2005: IEC 61215 Ed. 2 (c-Si)
  - Wet leakage current test taken from IEC 61646
  - Bypass diode test taken from IEEE 1262
  - Current flow during Thermal cycling test introduced
- 2008: IEC 61646 Ed. 2 (TF – a-Si, CdTe, CIGS)
  - Attempt to extend validity to new TF technologies (CdTe, CIGS)
  - Adapted pass/fail criteria to final power after stress tests
  - Adapted Hot-spot test method, Bypass diode test introduced

Recent modifications of IEC guidelines

Motivation for the adaption of the IEC 61215 standard structure

- Alignment of requirements for crystalline Si and various thin-film technologies
- No differentiation in minimum requirements
- Clear structure with

- general requirements
- test methods
- technology specific parts

- Consistence with other international standards
- Possibility to react quickly to new technology developments with individual standard parts
- **IEC 61215-1, -1-1 and -2 published in March 2016**
- **Thin-film parts IEC 61215-1-2 through 1-4 published in December 2016**
- Other technology specific parts (-1-x) are being developed

Recent modifications of IEC guidelines

Motivation for the rework and restructuring of IEC 61730

- IEC 61730 has always been a bad compromise between EU guidelines and ANSI/UL 1703.
- Many outdated test requirements, imperfect formulations and (too) much room for interpretation
- Adaption to meet general IEC guidelines for standard structures
- Alignment with general „horizontal“ standards, e.g. IEC 60664
- Consideration of new technology developments
- Full extension to 1500 V DC system voltage
- Incorporation of existing component standards
  - Cable EN50618 (IEC 62930 is under development, will replace EN 50618)
  - Connector IEC 62852
  - Junction box IEC 62790
- **IEC 61730-1 and -2 published in August 2016**

Content

- Basic understanding of the recent modifications of the IEC guidelines for PV modules
- Review of IEC 61215:2016 (type approval) - general requirements and test methods
- Review of IEC 61730-1:2016 (safety qualification) - requirements for construction
- Review of IEC 61730-2:2016 (safety qualification) - requirements for testing
- Transitional periods
- Closing remarks

Review of IEC 61215:2016 (type approval)

Previous status

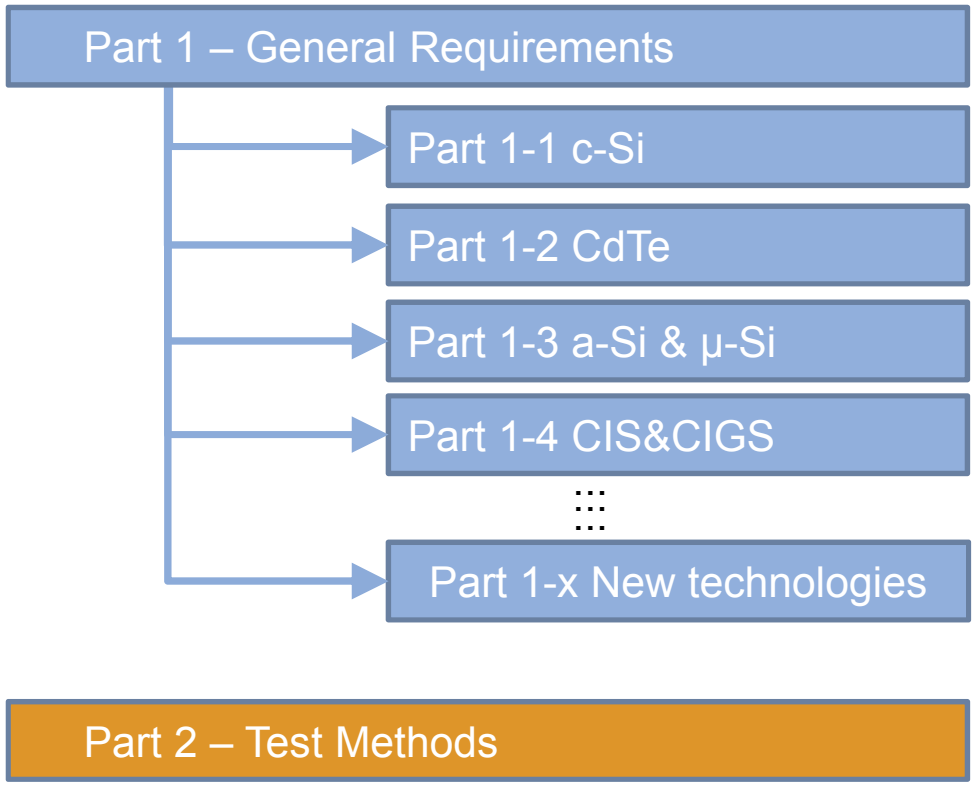
IEC 61215 Ed. 2 Requirements

IEC 61215 Ed. 2 Test Methods

IEC 61646 Ed. 2 Requirements

IEC 61646 Ed. 2 Test Methods

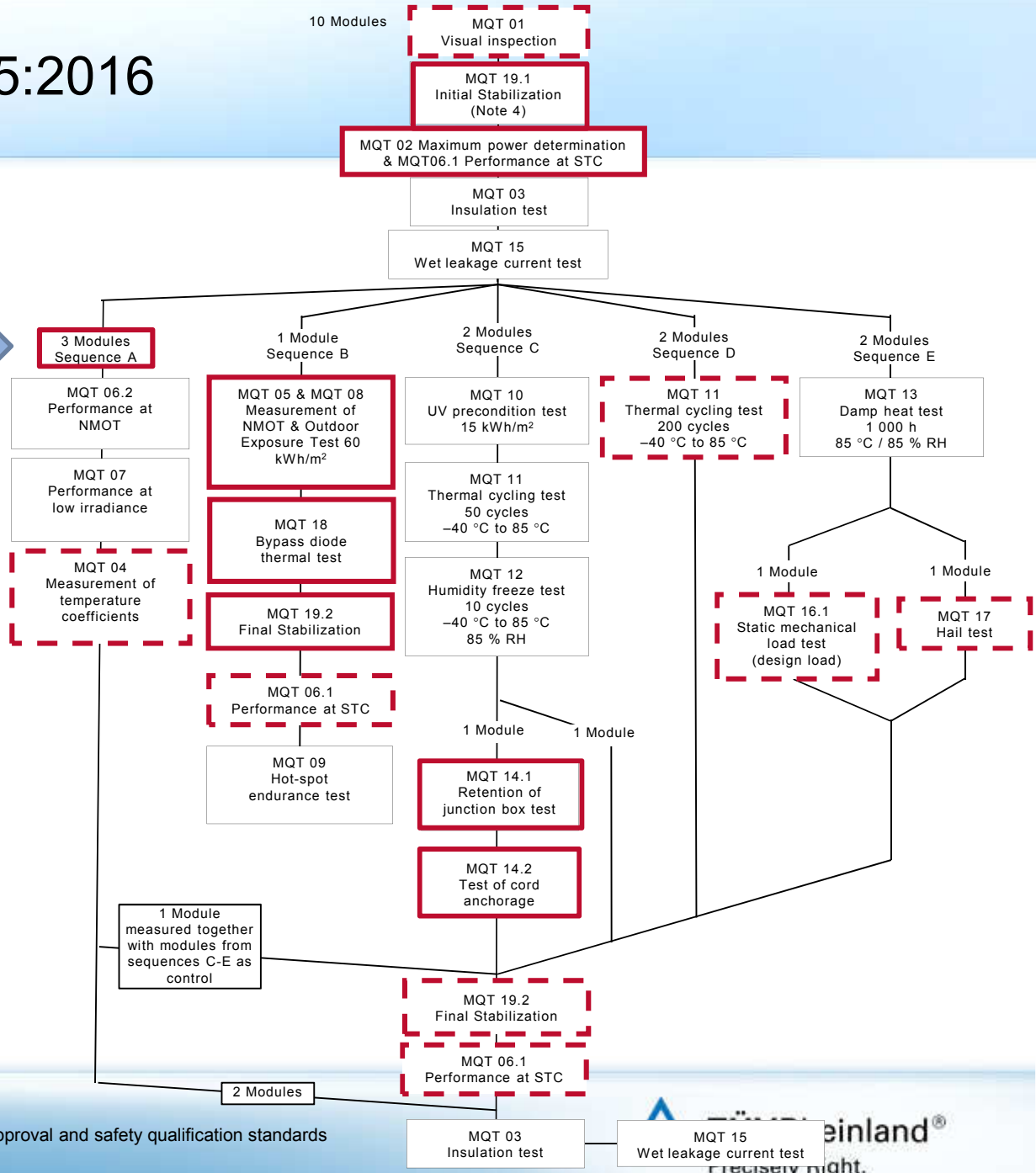
New IEC 61215 series



Review of IEC 61215:2016

Adapted or new test methods

Sequence designation

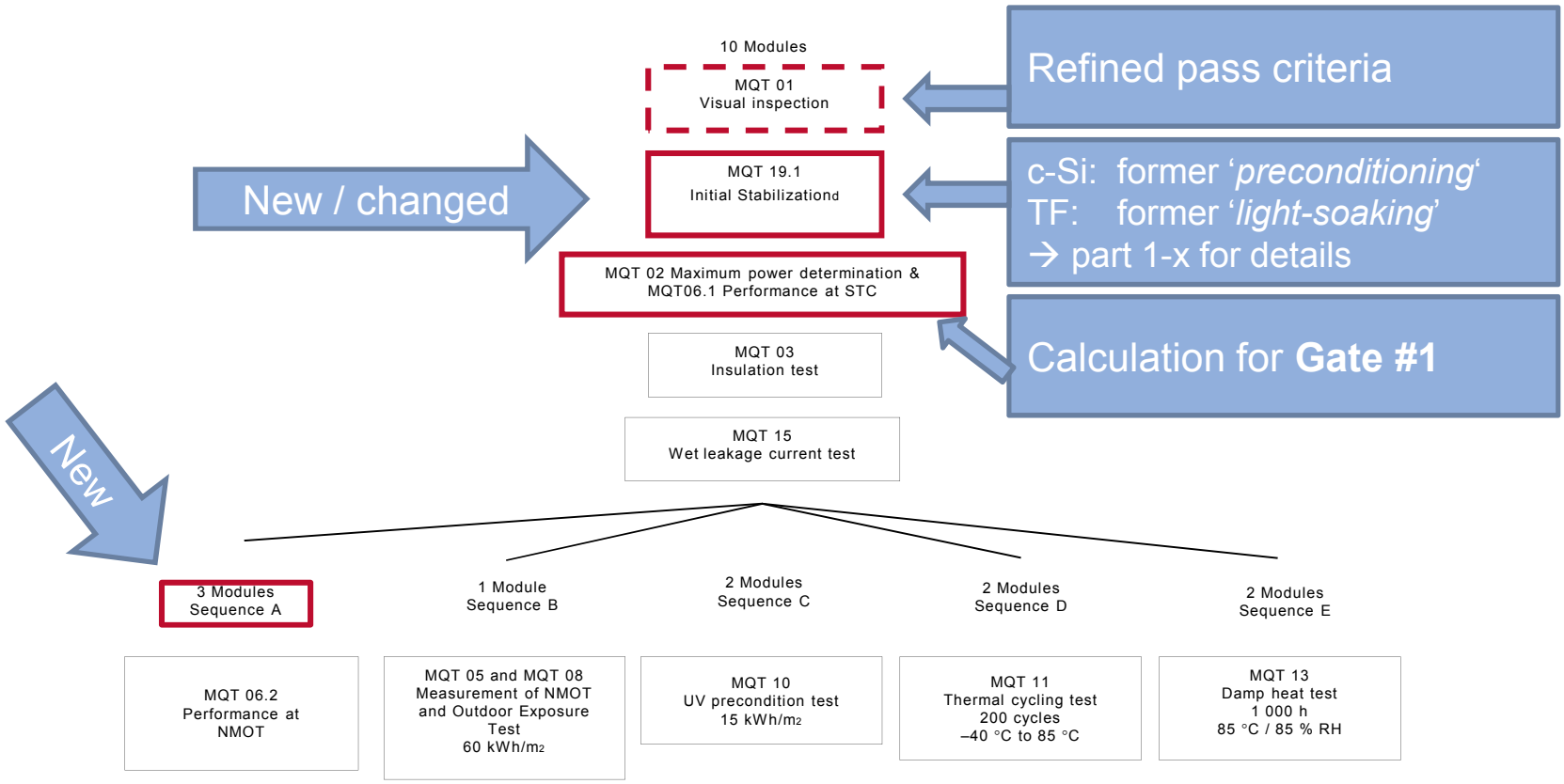


Definition:

Module **Q**uality **T**ests (MQT)
→ IEC 61215 Type approval

Module **S**afety **T**ests (MST)
→IEC 61730 Safety requirements

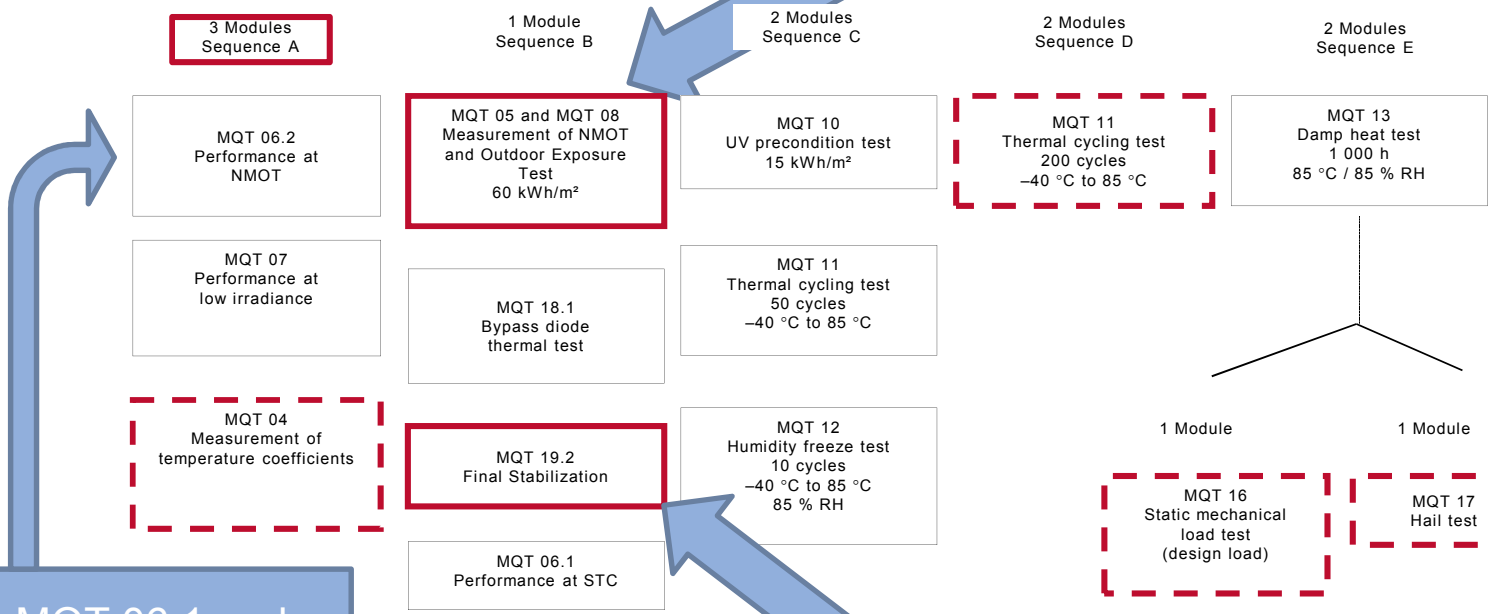
Review of IEC 61215:2016 (type approval)



Review of IEC 61215:2016 (type approval)

Changed and separated into two sequences (A+B)

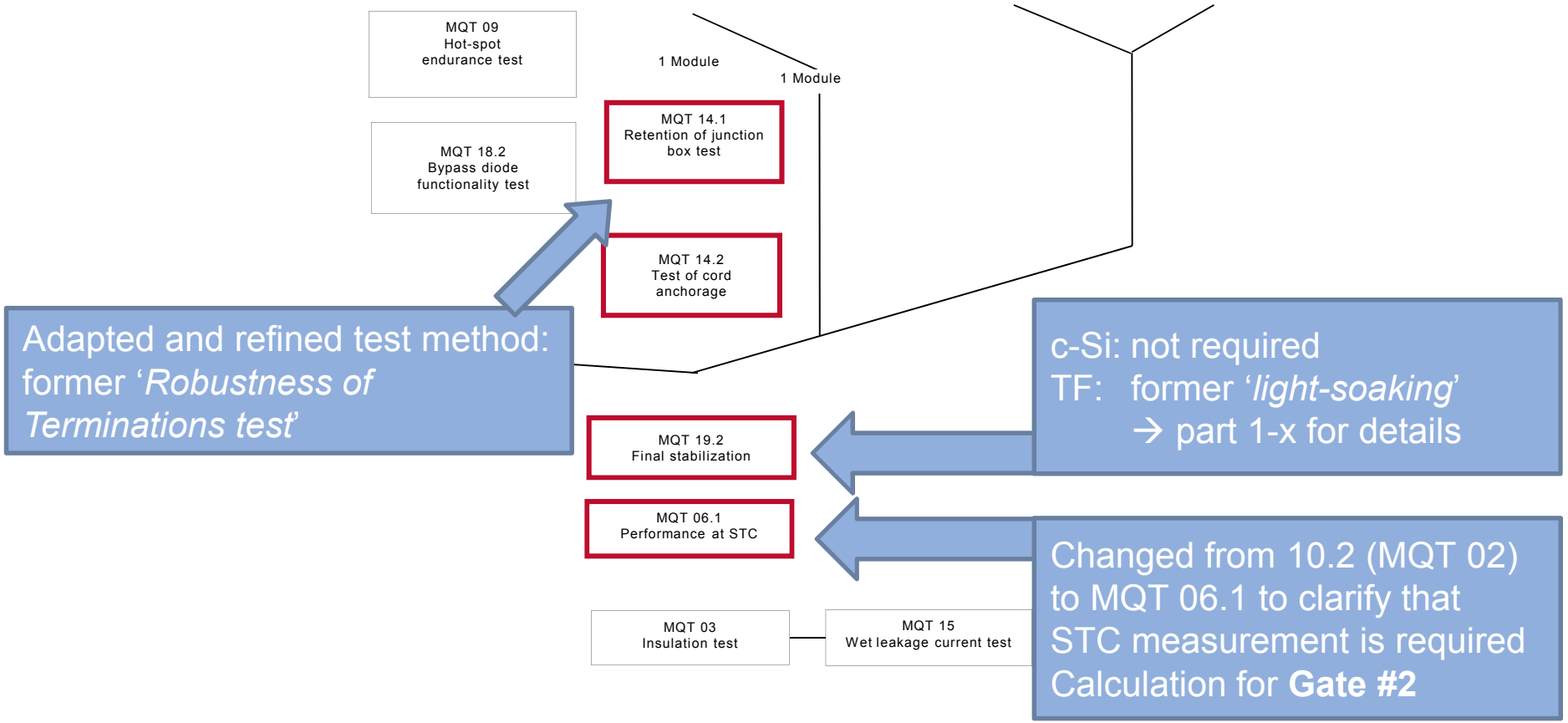
NMOT (former NOCT):
Nominal Module Operating Temperature
Improvement of data base



MQT 06.1 and 06.2 with clear separation

c-Si: not required
TF: former '*light-soaking*'
→ part 1-x for details

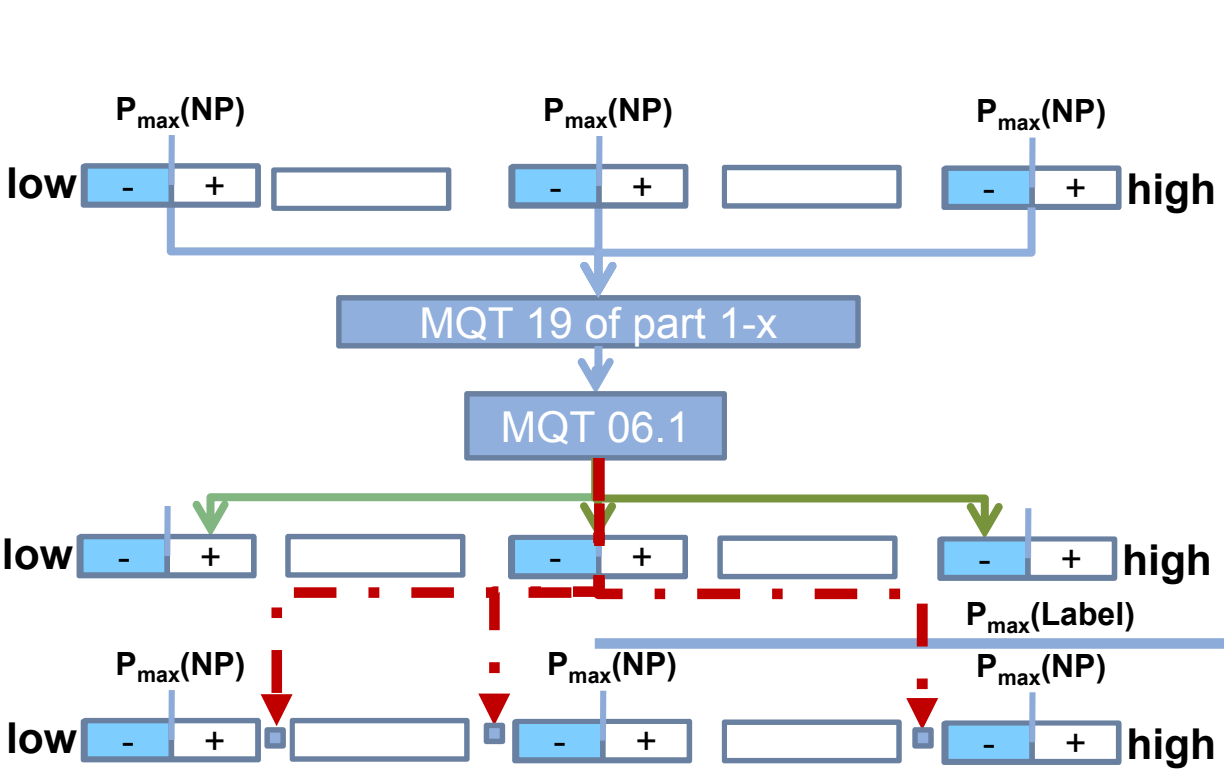
Review of IEC 61215:2016 (type approval)



Review of IEC 61215:2016 (type approval)

Gate #1: Type label power assessment (pass criteria at the begin of a sequence; Clause 7 of IEC 61215-1)

→ Confirmation of nominal output power of type label including tolerances



P_{max} (NP): Nominal power (name plate)
- : negative tolerance of NP
+ : positive Tolerance of NP

Pass: Measured power incl. measurement uncertainty (MU) lays within the given tolerances.

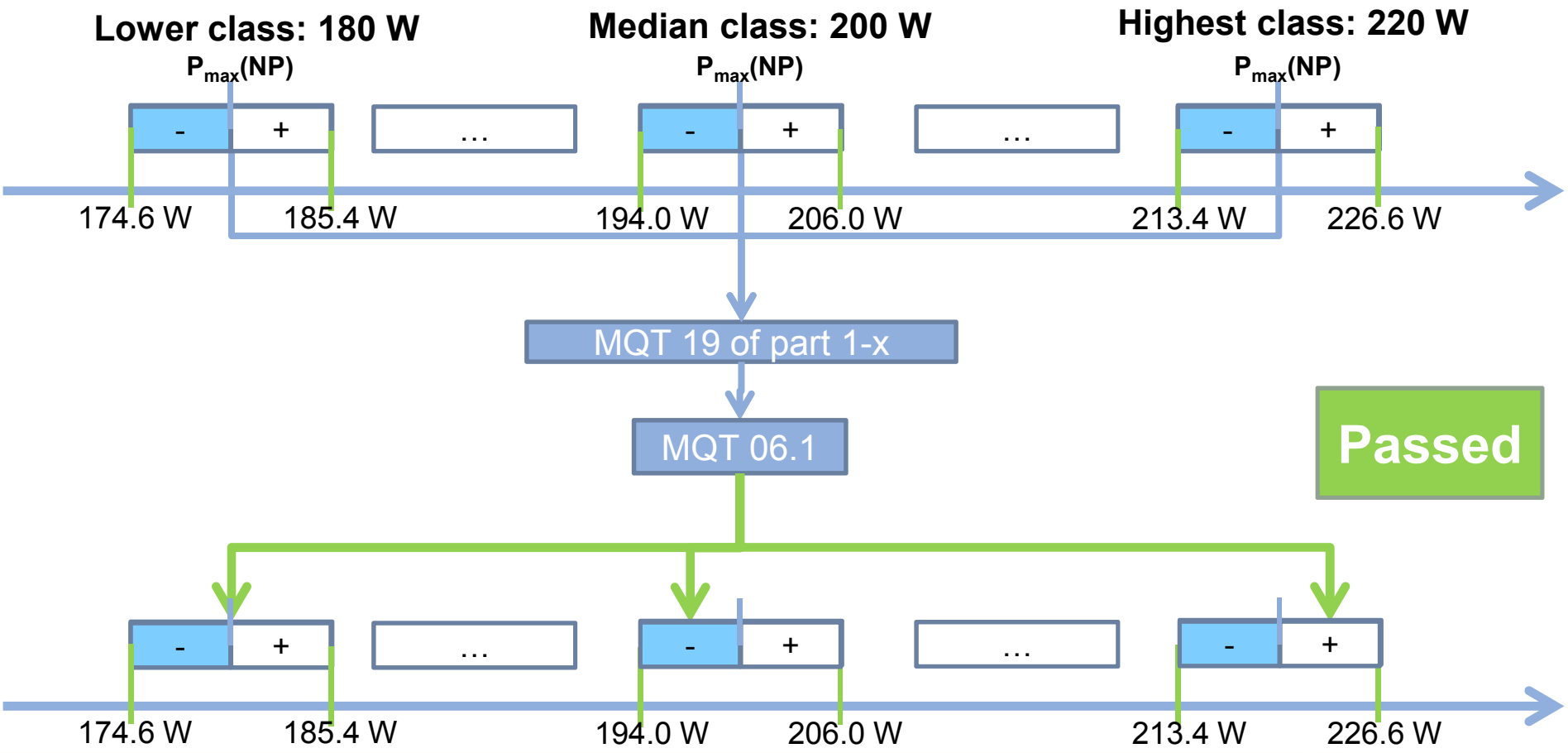
Fail: One or more modules have a power outside the given tolerances after consideration of the measurement uncertainty.

Pass

Fail

Review of IEC 61215:2016 (type approval)

Example:
Module family for certification: power classes 180 W to 220 W and tolerance ± 3 %



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Review of IEC 61215:2016 (type approval)

Example:
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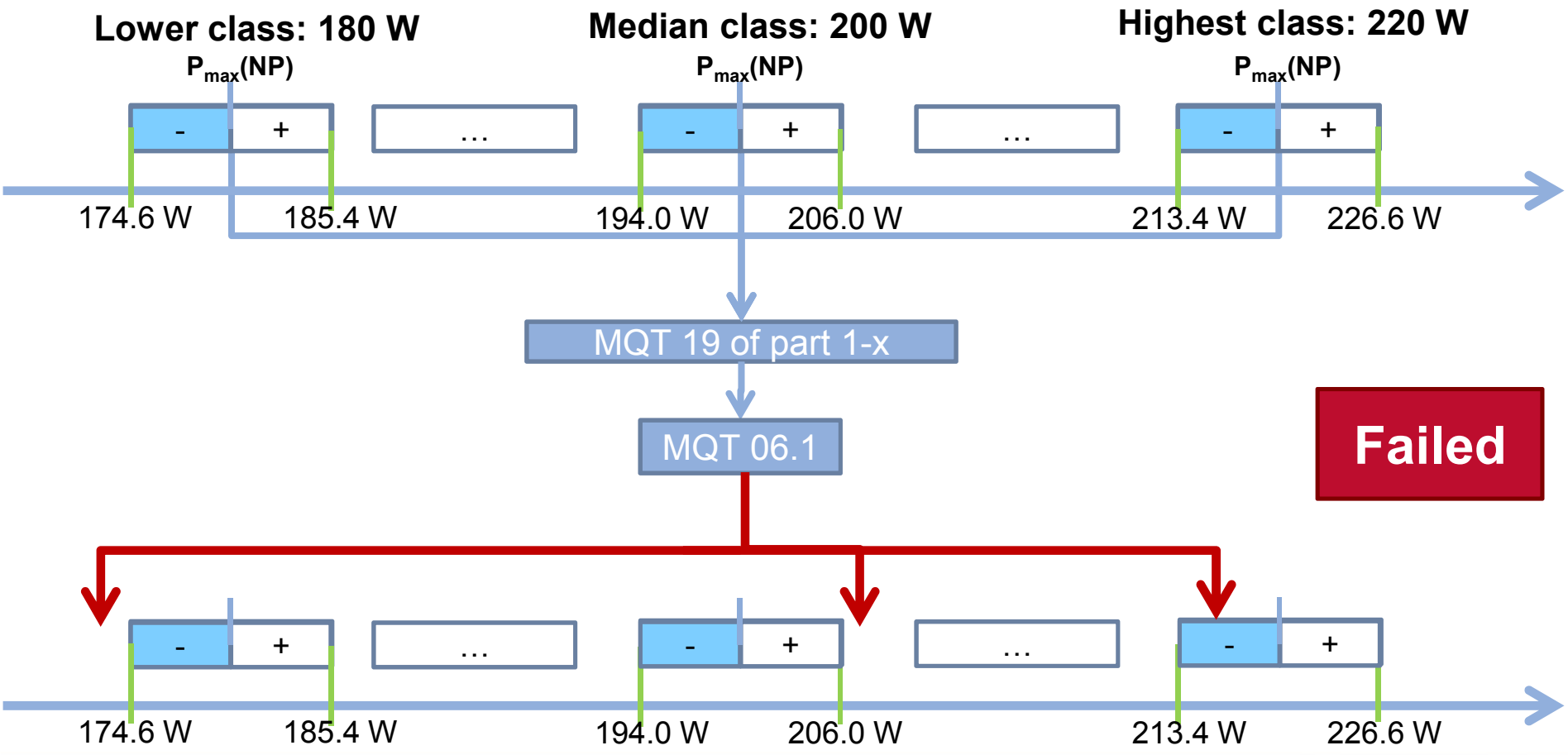

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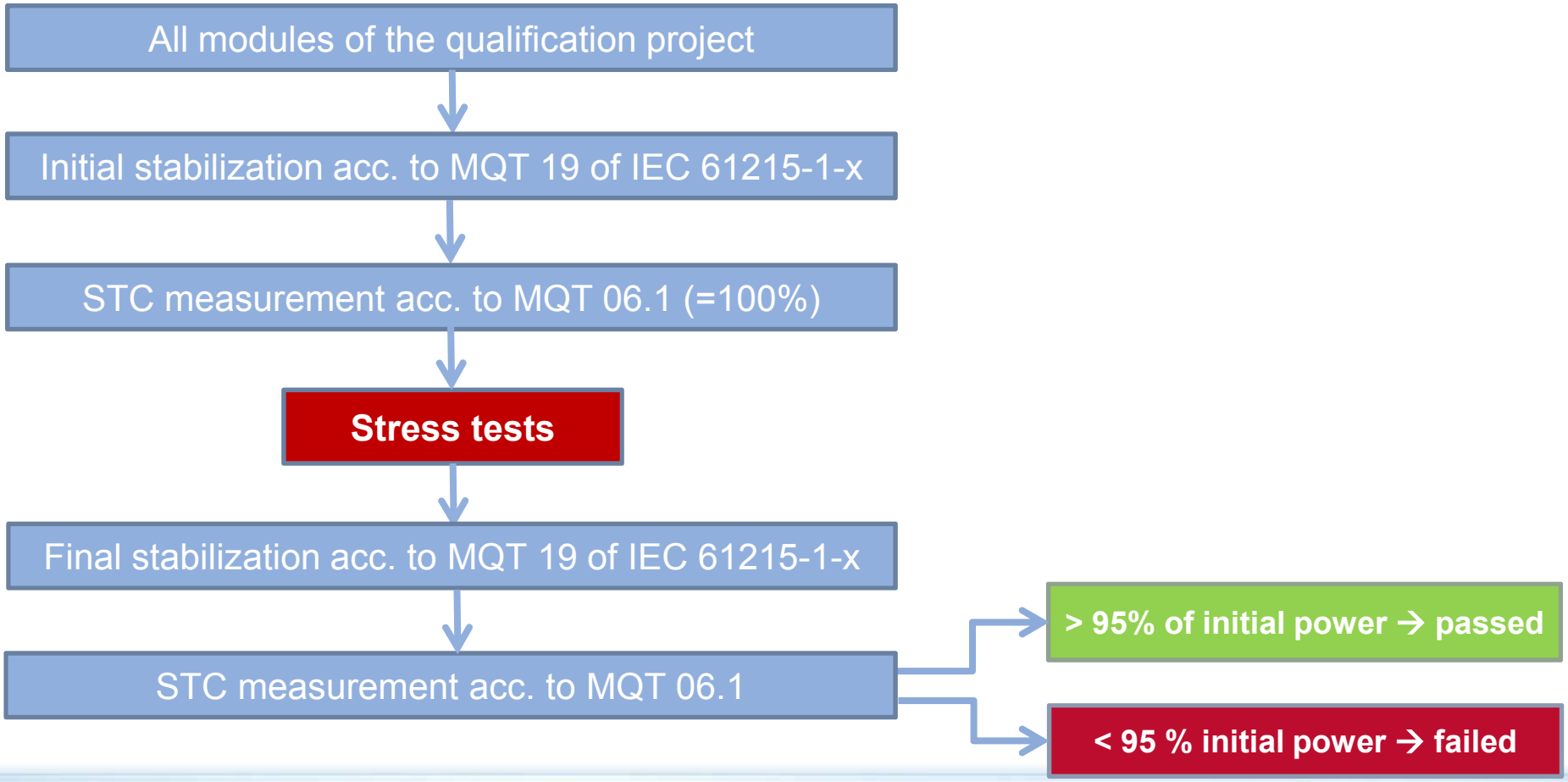
Gate #2: Power degradation (pass criteria at the end of a sequence)
→ 95% of stabilized initial power minus reproducibility (assessment per module)



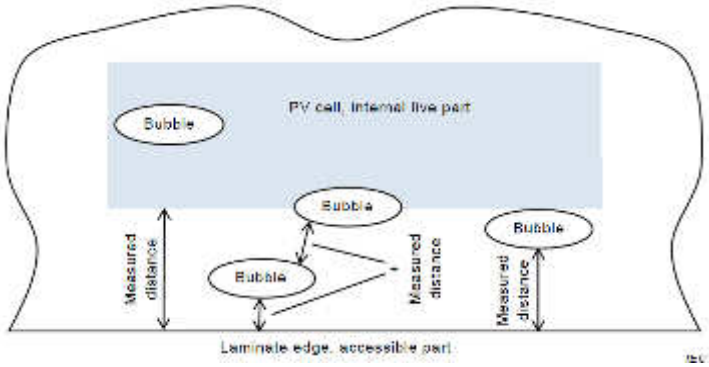
Review of IEC 61215:2016 (type approval)

General requirements and regulations (IEC 61215-1)

- IEC norms can be taken as basis for low concentrator modules (1-3 suns)
- If several power classes to be approved (within the limits of IEC/TS 62915):
  2 modules to be taken from lower and upper end and from median of distribution
- Type label: tolerance for P_{max}, I_{sc}, V_{oc} required
- Type label verification: For each module type label values (P_{max}, I_{sc}, V_{oc}) to be confirmed by measurements
- Testing: Intermediate measurements of output power (MQT 02) and insulation resistance (MQT 03/MST 16) *optional,* partly relevant for IEC 61730
- Pass criteria: Max. 5 % degradation in output power allowed per test sequence
- Test failures: If test failure for one module, two additional modules to be subjected to the entire series of tests of the respective test sequence
- Design modifications (clause 10; retesting) → for new material *combinations* principally retests required → IEC TS 62915

Review of IEC 61215:2016 (type approval)

MQT 01 – Visual inspection

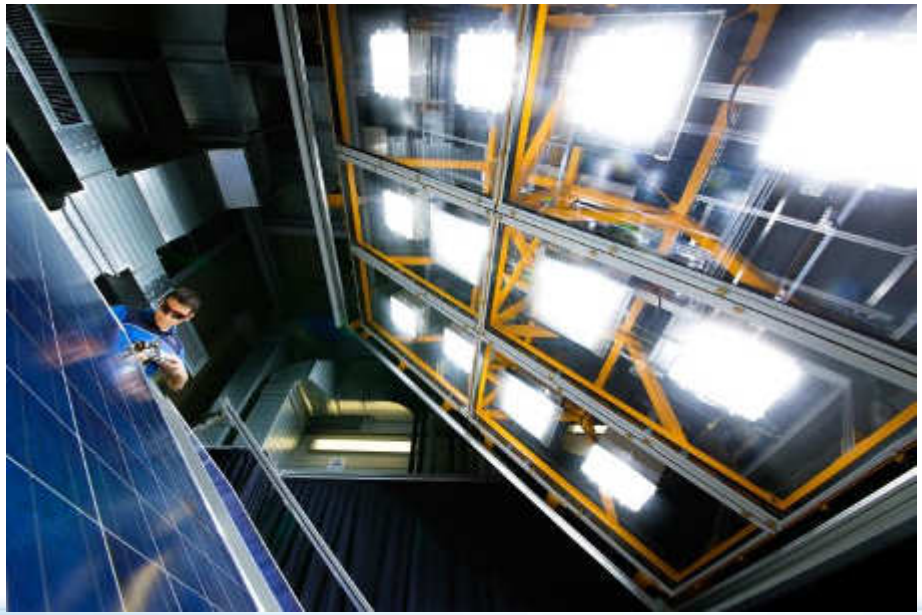


- Purpose: Detection of any visual defects in the module
- Major visual defects defined in IEC 61215-1:
  - Broken, cracked or torn external surfaces
  - Bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the PV module operation would be impaired
  - Bubbles or delamination forming a continuous path between electric circuit and edge of module
  - If the mechanical integrity depends on lamination or other means of adhesion, the sum of the area of all bubbles shall not exceed 1 % of the total module area **(new)**
  - Evidence of any molten or burned encapsulant, backsheet, frontsheet, diode or active PV component **(new)**
  - Loss of mechanical integrity to the extent that module installation and operation would be impaired **(new)**
  - Cracked/broken cells which can remove more than 10 % of the cell's photovoltaic active area from the electrical circuit of the PV module **(new)**
  - Voids in or visible corrosion of any of the layers of the active (live) circuitry of the module extending over more than 10 % of any cell **(new)**
  - Broken interconnections, joints or terminals
  - Any short-circuited live parts or exposed live electrical parts
  - Module markings (label) no longer attached / information no longer readable **(new)**
- Partly more testing may be required to finally decide if major visual defects exist

Review of IEC 61215:2016 (type approval)

MQT 02 – Maximum power determination

- Minor changes (specifications for test equipment)
- Purpose: Determination of maximum output power of modules after stabilization and before and after environmental stress tests.
- For power loss determination, reproducibility has to be considered.
- Requirements for simulator and for performance measurements slightly changed



Review of IEC 61215:2016 (type approval)

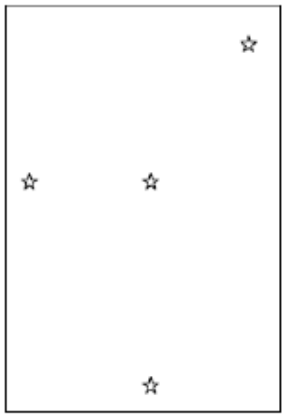
MQT 03 – Insulation test

- No changes compared to previous standards
- Purpose: To determine if module is sufficiently insulated between live parts and accessible parts
  - V_{test} = 2 x V_{MaxSys} + 1000 V_{DC} (1 min) → no dielectric breakdown
  - V_{test} = V_{MaxSys} (2 min) → R_{iso} x module area > 40 MΩ*m²

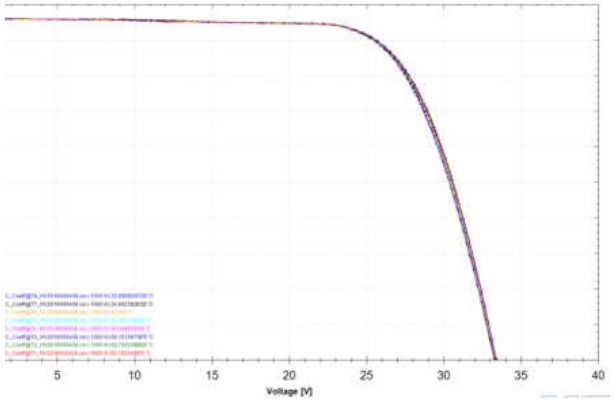
Review of IEC 61215:2016 (type approval)

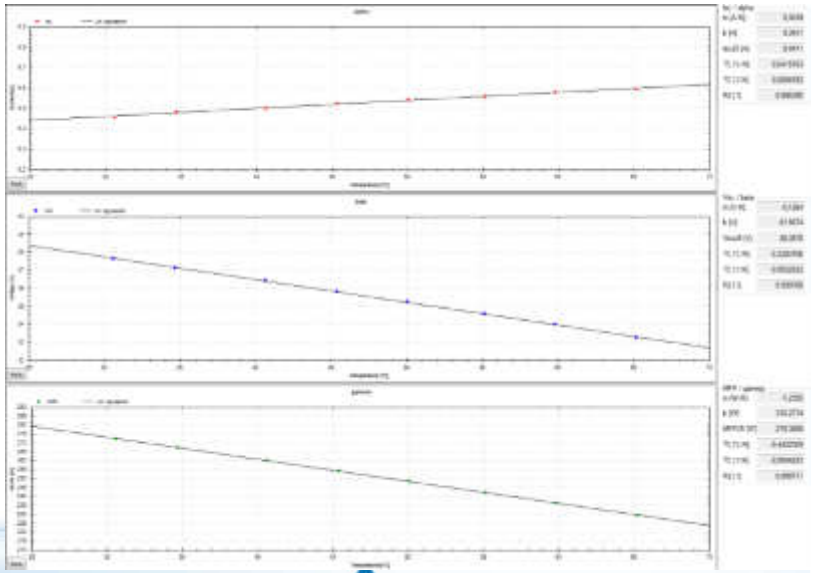
MQT 04 – Temperature coefficients

- Minor changes (specifications for test equipment and performance)
- Reference for measurement: IEC 60891:2009
- Array of temperature sensors precisely defined (4 positions, behind cells)
- Extrapolation to G = 1000 W/m² within linearity region permitted (1000 W/m² ± 30 %)
- Complete IV-curve to be measured
- Calculated coefficients only apply to spectrum during measurement



Module temperature measurement positions





Review of IEC 61215:2016 (type approval)

MQT 05 – Measurement of nominal module operating temperature (NMOT)

- Major changes
- NMOT: similar to former NOCT except that it is measured with module under maximum power rather than in open-circuit
- Under maximum power conditions electric energy is withdrawn from the module, therefore less thermal energy dissipates throughout the module than under open-circuit conditions → typically NMOT < NOCT
- NMOT is determined at T_{amb} = 20 °C, irradiance G = 800 W/m², wind speed v = 1 m/s
- Tilt angle: 37° (± 5°)
- Average of four temperature sensors taken
- Measurement over at least 10 days
- Can be performed simultaneously with Outdoor exposure test (MQT 08)
- New value information for data sheets – **P@NMOT**

Review of IEC 61215:2016 (type approval)

MQT 06.1 – Performance at STC

- P(STC): 1000 W/m², 25 °C and AM1.5
- Requirements for simulator and for performance measurements slightly changed
- Requirements for nominal power (Gate #1) and maximum allowed degradation (Gate #2)

Gate #1	
$P_{max}(Lab) * \left(1 + \frac{\lvert m_1 \rvert [\%]}{100}\right) \geq P_{max}(NP) * \left(1 - \frac{\lvert t_1 \rvert [\%]}{100}\right)$	Criterion 1: P_{max} above the type label incl. tolerance for each module
$\bar{P}_{max}(Lab) * \left(1 + \frac{\lvert m_1 \rvert [\%]}{100}\right) \geq P_{max}(NP)$	Criterion 2: arithmetic average above the type label incl. tolerance
$V_{OC}(Lab) * \left(1 + \frac{\lvert m_2 \rvert [\%]}{100}\right) \leq V_{OC}(NP) * \left(1 + \frac{\lvert t_2 \rvert [\%]}{100}\right)$	Criterion 3: Voc below the type label incl. tolerance for each module
$I_{SC}(Lab) * \left(1 + \frac{\lvert m_3 \rvert [\%]}{100}\right) \leq I_{SC}(NP) * \left(1 + \frac{\lvert t_3 \rvert [\%]}{100}\right)$	Criterion 4: Isc below the type label incl. tolerance for each module

Gate #2	
$P_{max}(Lab, final) \geq 0.95 * P_{max}(Lab, initial) * \left(1 - \frac{r[\%]}{100}\right)$	Control measurement: Degradation below 5%

$m_{1,2,3}$: measurement uncertainty of test lab; t_1: manufacturer's rated lower production tolerance;
$t_{2,3}$: manufacturer's rated upper production tolerance; r: reproducibility of measurements

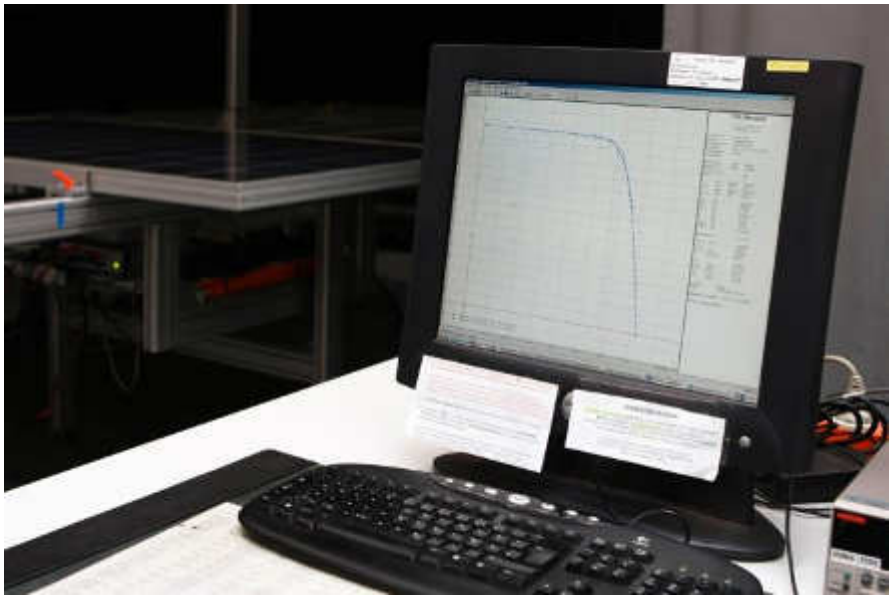
Review of IEC 61215:2016 (type approval)

MQT 06.2 – Performance at NMOT

- P(NMOT): 800 W/m², NMOT and AM1.5
- Analogous to measurement of previous standards

MQT 07 – Performance at low irradiance

- P(LI): 200 W/m², 25 °C and AM1.5
- No changes compared to previous standards



Review of IEC 61215:2016 (type approval)

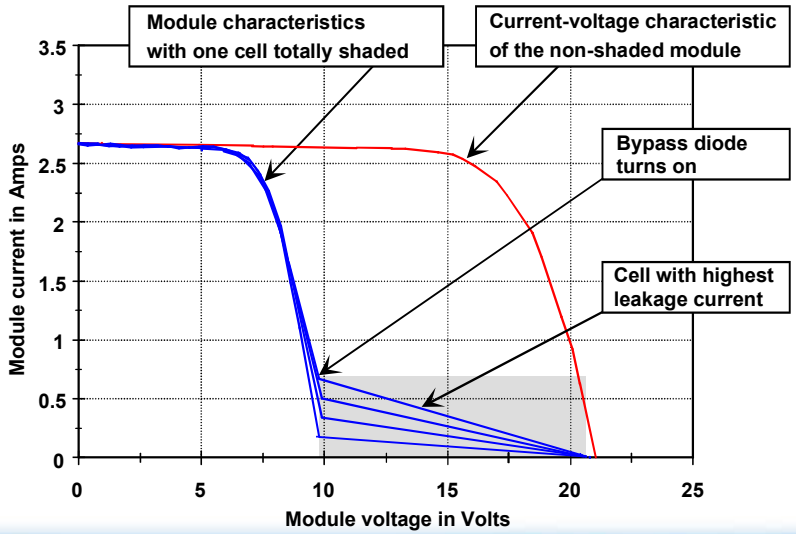
MQT 08 – Outdoor exposure test

- Minor changes
- Purpose: Assessment of module ability to operate in outdoor conditions
- Module subjected to irradiation totaling at least 60 kWh/m²
- Module shall operate near maximum power point (use of resistive load or electronic power point tracker)
- Outdoor exposure and NMOT determination may be performed simultaneously on the same module
- Control measurements:
  - MQT 01 (Visual inspection)
  - MQT 15 (Wet leakage current test)

Review of IEC 61215:2016 (type approval)

MQT 09 – Hot-spot endurance test (wafer-based technologies)

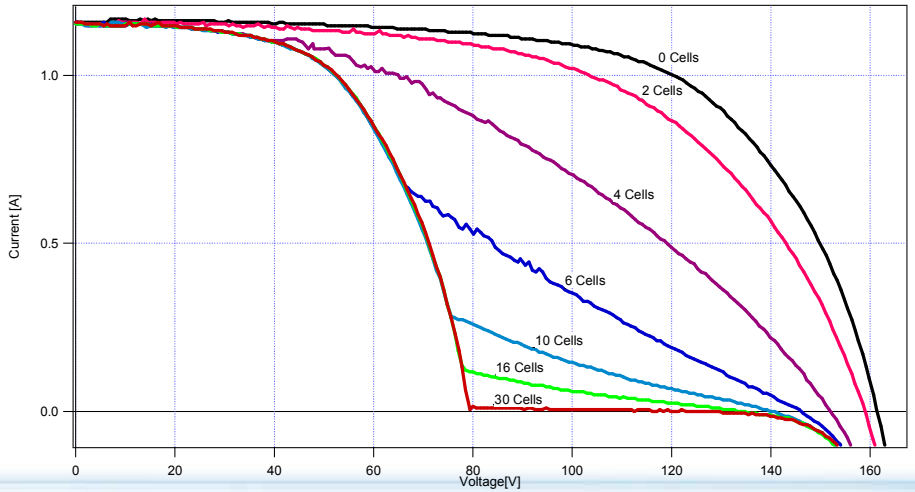
- Minor changes
- Purpose: To determine module ability to withstand hot-spot heating effects
- Classification of cell interconnection: case S (serial), case PS (parallel-serial), case SP (serial-parallel)
- Selection of four test cells (lowest shunt resistance cell at module edge, (in addition) two lowest shunt resistance cells, highest shunt resistance cell)
- Determination of worst-case shading
- Maintenance of worst-case shading condition for 1h for each selected cell. If temperature of shadowed cell is still increasing after 1h: total exposure time 5h.
- Control measurements:
  - MQT 01 (Visual inspection)
  - MQT 02 (Max. power det.) (functional control)
  - MQT 03 (Insulation test)
  - MQT 15 (Wet leakage current test)



Review of IEC 61215:2016 (type approval)

MQT 09 – Hot-spot endurance test (monolithically integrated technologies)

- Minor changes
- Classification of cell interconnection: case S (serial), case PS (parallel-serial), case SP (serial-parallel)
- Determination of worst-case shading of cell (block), procedure depending on cell interconnection
- Maintenance of worst case shading condition for 1h
- CdTe / CIGS: time between Outdoor exposure test and Hot-spot endurance test < 2-3 d; storage at ≤ 25 ºC (in darkness)
- Control measurements:
  - MQT 01 (Visual inspection)
  - MQT 02 (Max. power det.)
    (functional control)
  - MQT 03 (Insulation test)
  - MQT 15 (Wet leakage current test)



Review of IEC 61215:2016 (type approval)

MQT 10 – UV preconditioning test

- Minor changes
- Purpose: Preconditioning of modules with ultra-violet radiation in order to identify materials being susceptible to UV degradation
- Module front side to be exposed
- Module operation mode changed:

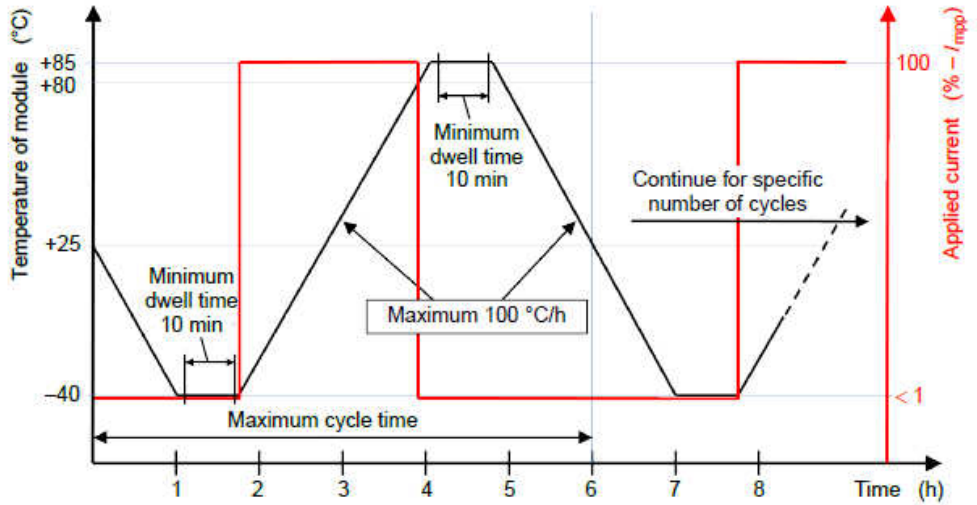
- under load (MPP), if light source with significant fraction in visual region (> 20 % contribution to $P_{mpp,STC}$)
- **at short-circuit**, if light source with negligible fraction in visual region (investigations prove, that most technologies match this item)

- Control measurements:
  - MQT 01 (Visual inspection)
  - MQT 15 (Wet leakage current test)
- More severe test included in IEC 61730

Review of IEC 61215:2016 (type approval)

MQT 11 – Thermal cycling test

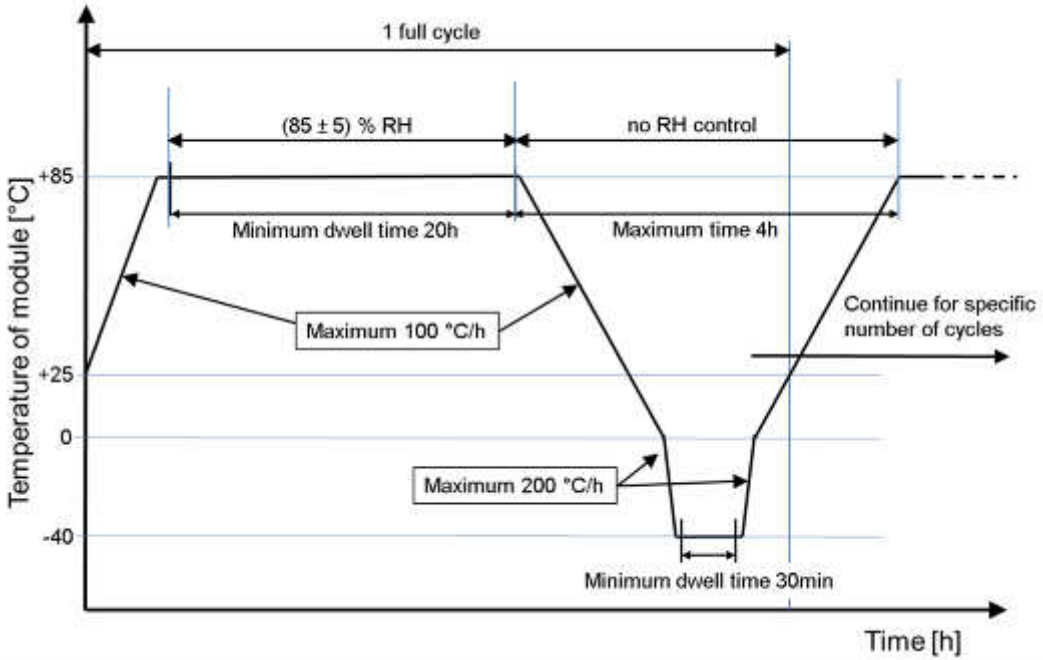
- Minor changes
- Purpose: To determine module ability to withstand thermal stresses caused by repeated temperature changes
- Applicable for TC 200 and TC 50
- Applied current 0.1* $I_{mpp,STC}$ or 1* $I_{mpp,STC}$ (dependent on technology), only during heating phase (else: < 0.01* $I_{mpp,STC}$)
- Control measurements after recovery time of > 1h at 23°C ± 5°C and r.H. ≤ 75%:
  - MQT 01 (Visual inspection)
  - MQT 15 (Wet leak. current test)



Review of IEC 61215:2016 (type approval)

MQT 12 – Humidity freeze test

- No changes
- Purpose: Investigation of module ability to withstand high temperature and humidity followed by sub-zero temperatures
- Control measurements after recovery time of 2-4 h at 23 ± 5°C and r.H. ≤ 75 %:
  - MQT 01 (Visual inspection)
  - MQT 15 (Wet leakage current test)



Review of IEC 61215:2016 (type approval)

MQT 13 – Damp heat test

- Minor changes
- Purpose: To determine the module ability to withstand long-term penetration of humidity
- No preconditioning at room temperature required
- Test duration 1000 h -0/+48 h
- Control measurements after recovery time of 2-4 h at 23 ± 5°C and r.H. ≤ 75%:
  - MQT 01 (Visual inspection)
  - MQT 15 (Wet leakage current test)

Review of IEC 61215:2016 (type approval)

MQT 14 – Robustness of terminations

- Major changes
- Purpose: To verify that terminations, its attachment and the cable attachment can withstand stresses caused by assembly or handling operations

MQT 14.1 – Retention of junction box on mounting surface

- 2-4 h after Humidity freeze test
- Force of 40N applied for 10s in the module plane
  (four directions in steps of 90°) and perpendicular to junction box
- Control measurements: MQT 01 (Visual inspection),
  MQT 15 (Wet leakage current test)

MQT 14.2 – Test of cord anchorage

a) Cable pull test: 50x pulling load for 1s, force depending on cable diameter
b) Cable torque test: torque on cable for 1min, torque depending on cable diameter

- Control measurements: MQT 01 (Visual insp.), MQT 03 (Insulation test),
  MQT 15 (Wet leakage current test)
- **Test not necessary if junction box certified acc. to IEC 62790**

Review of IEC 61215:2016 (type approval)

MQT 15 – Wet leakage current test

- Mostly as in previous standards
- Purpose: Investigation of module insulation under wet operating conditions
- Connectors are sprayed wet
- Different polarity measurement possible
- Temperature range: 22 °C ± 2°C

Review of IEC 61215:2016 (type approval)

MQT 16 – Static mechanical load test

- Minor changes
- Purpose: To determine the module ability to withstand a minimum static load
- Design load and safety factor (γ_m) needs to be declared by customer:
  - Minimum for design load ≥ 1,600 Pa (individually for positive (downward) and negative (upward) loads)
  - Minimum for safety factor $\gamma_m \geq 1.5$
  - → Minimum pressure 2,400 Pa
- Each mounting method needs to be considered or covered by worst-case testing.
- Design load and mounting method with maximum load need to be documented in the installation manual.
- Control measurements:
  - MQT 01 (Visual inspection)
  - MQT 15 (Wet leakage current test)

Test load = γ_m x Design load

Review of IEC 61215:2016 (type approval)

MQT 17 – Hail test

- Minor changes
- Purpose: To verify the module ability to withstand the impact of hail
- No changes for 25 mm ice balls
- Ice ball diameter according to table
- Minimum of 10 shots to specific points
- Control measurements:

  MQT 01 (Visual inspection),

  MQT 15 (Wet leakage current test)

Diameter [mm]	Mass [g]	Test velocity [m/s]
25	7.53	23.0
35	20.7	27.2
45	43.9	30.7
55	80.2	33.9
65	132.0	36.7
75	203.0	39.5

Review of IEC 61215:2016 (type approval)

MQT 18 – Bypass diode testing

- Major changes
- Purpose: To assess the thermal design and long-term reliability of the used bypass diodes and to verify that they are still functional afterwards

MQT 18.1 – Bypass diode thermal test

New test procedure:

1) Determination of characteristic

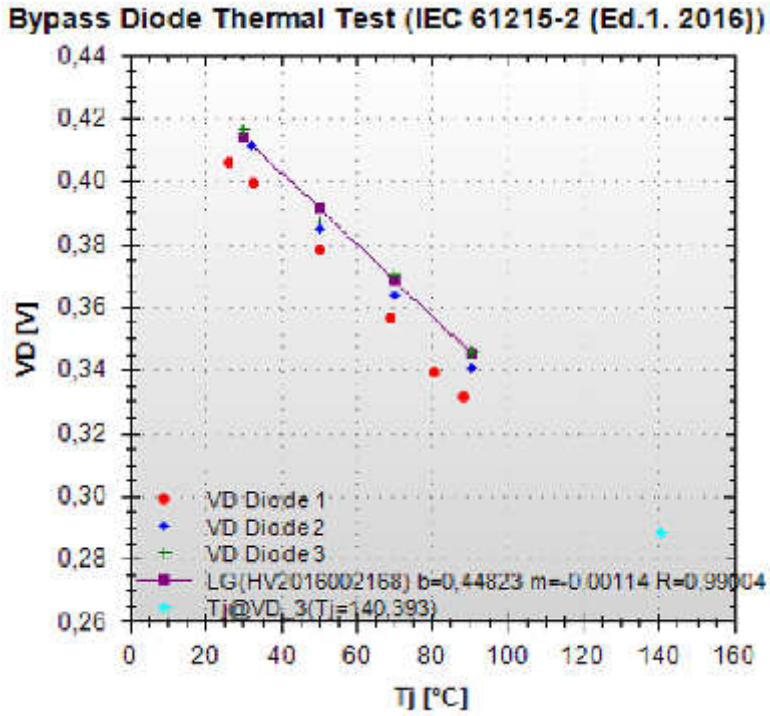
- VD (diode forward voltage) vs. TJ (junction temperature)
- Module heated to T_{J1-4} = 30/50/70/90°C, pulsed I_{sc} (1ms) applied, V_{D1-4} measured
- Plot: V_D vs. T_J characteristic

2) Test performance: determination of T_J at T_{amb}=75°C

- Module heated to 75°C ± 5°C, current I_{sc}(STC) applied for 1 hour
- After 1 hour: V_D of each diode measured
- T_J obtained from extrapolation of V_D vs. T_J characteristic

3) Test performance: higher current

- Applied current increased to 1.25 * I_{SC} for 1 h at 75°C ± 5°C



Control measurements: MQT 01 (Visual inspection), MQT 15 (Wet leakage current test), MQT 18.2

Review of IEC 61215:2016 (type approval)

MQT 18 – Bypass diode testing

MQT 18.2 – Bypass diode functionality test

Functionality test after MQT 09 (Hot-spot endurance test) and MQT 18.1 (Bypass diode thermal test)

- **Method A (dark current)**:

PV module covered; current applied in sweep from 0 – 1.25 * Isc through solar cells in reverse direction and through the diode in forward direction.

Requirement: measured diode forward voltage

VFM = (N x $V_{FMrated}$) ± 10 %

(N = number of bypass diodes, $V_{FMrated}$ = diode forward voltage at 25°C (data sheet))

- **Method B (flash light simulator):**

IV-curve measurement by covering each string

Diode is working properly, if PV module has approx. 2/3 performance when 1 diode protects 1/3 of the PV module.

Review of IEC 61215:2016 (type approval)

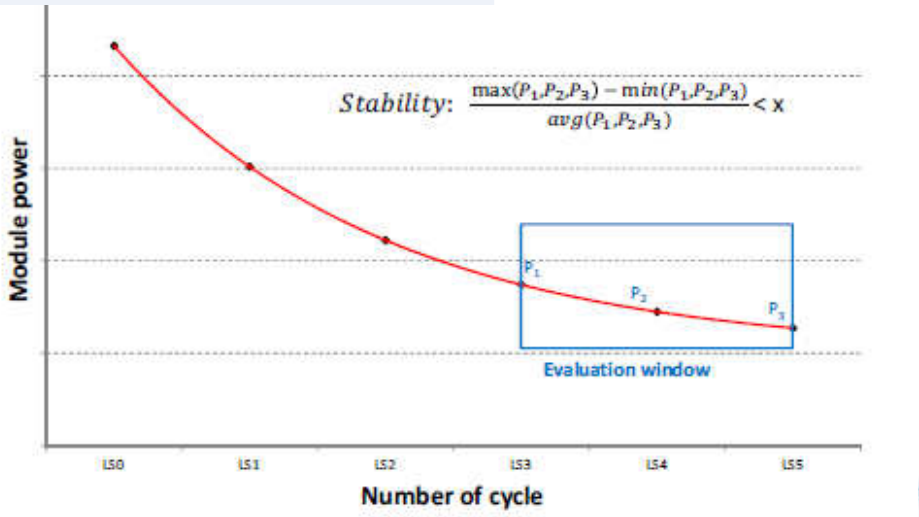
MQT 19 – Stabilization

- New requirement for c-Si (former *preconditioning*); corresponds to former *light-soaking* for thin-film
- Applied irradiance:

Cell	Min. irradiance initial stabilization	Min. irradiance final stabilization	Requirement for x (specified in IEC 61215-1-NN)
c-Si	2 * 5 kWh/m²	-	0.01
CdTe	2 * 20 kWh/m²	2 * 20 kWh/m²	0.02
a-Si	2 * 43 kWh/m²	2 * 43 kWh/m²	0.02
CIGS	2 * 10 kWh/m²	2 * 10 kWh/m²	0.02

- Calculation of stability:

$$(P_{max} - P_{min}) / P_{average} < x$$



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Content

Review of IEC 61730:2016 (safety qualification)

Previous status

IEC 61730-1 Ed. 1
Requirements for construction

IEC 61730-2 Ed. 1
Requirements for testing

New IEC 61730

IEC 61730-1 Ed. 2
Requirements for construction

IEC 61730-2 Ed. 2
Requirements for testing

Review of IEC 61730-1:2016 (safety qualification)

Table 3 – Distances through insulation, creepage distances (cr) and clearances (cl) for Class II PV modules

	pollution degree	Distances in mm																							
		≤35 V DC [a,d]				100 V DC [a]				150 V DC [a]				300 V DC [a]				600 V DC [a]				1 000 V DC [a]				1 500 V DC [a]			
		cl	cr			cl	cr			cl	cr			cl	cr			cl	cr			cl	cr			cl	cr		
			Material group				Material group				Material group				Material group				Material group				Material group				Material group		
Between			I	II	III		I	II	III		I	II	III		I	II	III		I	II	III		I	II	III		I	II	III
1a) Internal live parts and outer accessible surfaces	1	0,5 [b, c]	0,4			1,5 [b]	0,5			3,0 [b]	0,6			5,5 [b]	1,4			8,0 [b]	3,4			14,0 [b]	6,4			19,4 [b]	10,4		
	2		1,2	1,7	2,4		1,4	2,0	2,8		1,6	2,2	3,1		3,0	4,2	6,0		6,1	8,6	12,0		10,0	14,2	20,0		15,0	20,8	30,0
	3		3,0	3,4	3,8		3,6	4,0	4,4		3,9	4,3	4,9		7,5	8,5	9,4		15,2	17,1	19,1		25,0	28,0	32,0		37,7	41,7	47,1
1b) Thickness of thin layers (see 5.6.4.3)	-	0,01				0,01				0,01				0,01				0,06				0,15				0,3			
2) Live parts of different potential inside a PV module	1	0,1	0,2			0,5 [b, c]	0,3			1,5 [b]	0,3			3,0 [b]	0,7			5,5 [b]	1,7			8,0 [b]	3,2			11,0 [b]	5,2		
	2	0,2	0,6	1,0	1,2		0,7	1,0	1,4		0,8	1,1	1,6		1,5	2,1	3,0		3,0	4,3	6,0		5,0	7,1	10,0		7,5	10,4	15,0
	3	0,8	1,5	1,7	1,9		1,8	2,0	2,2		2,0	2,2	2,5		3,8	4,2	4,7		7,6	8,6	9,5		12,5	14,0	16,0		18,9	20,9	23,6
3) Terminals of different polarity of rewireable junction boxes	1	0,5 [b, c]	0,4			1,5 [b]	0,5			3,0 [b]	0,6			5,5 [b]	1,4			8,0 [b]	3,4			14,0 [b]	6,4			19,4 [b]	10,4		
	2		1,2	1,7	2,4		1,4	2,0	2,8		1,6	2,2	3,1		3,0	4,2	6,0		6,1	8,6	12,0		10,0	14,2	20,0		15,0	20,8	30,0
	3		3,0	3,4	3,8		3,6	4,0	4,4		3,9	4,3	4,9		7,5	8,5	9,4		15,2	17,1	19,1		25,0	28,0	32,0		37,7	41,7	47,1
4) Distance through cemented joints	-	0,2				0,3				0,5				1,0				1,5				2,0				3,5			

[a] For lines 1a), 1b), 3) and 4) the relevant voltage which is applicable shall be the system voltage. For line 2) the working voltage between parts of different potential at STC is relevant. All values given in this table are rounded to one digit from IEC 60664-1.

[b] If a measured clearance is smaller than the minimum required clearance an impulse voltage test as specified in IEC 60664-1shall show that the distance is adequate. To assess clearances between internal live parts and outer accessible surfaces IEC 61730-2, MST 14 may be applied.

[c] This value is increased to 0,8 mm for pollution degree 3.

[d] For designs where working voltage is below 20 V values directly from IEC 60664-1 can be applied

Review of IEC 61730-1:2016 (safety qualification)
Definitions

Classification according to IEC 61140

Class (IEC 61140)	Application class (IEC 61730-1:2004)	Description
0	B	Application in restricted access area
I	Special installation measures required	Special installation measures required
II	A	Application in non-restricted access area
III	C	Basic protection by limitation of voltage (ELV)

influences

- permitted clearance and creepage distances (table 3 or 4)
- marking:

PV module Classification	Marking	Symbol
Class II	Marking according to IEC 60417-5172: Class II equipment	
Class 0	No marking	no symbol
Class III	Marking according to IEC 60417-5180: Class III equipment	

- required insulation:

Protection Class (IEC 61140)	Protection required against direct contact	Insulation betw. live parts and accessible metal parts	Insulation betw. live parts and accessible surfaces	Insulation between live parts of different potential of the same circuit
Class 0 (B)	Yes	B	B	B
Class II (A)	Yes	R	R	B
Class III (C)	No	F	F	F

F: functional insulation

B: basic insulation

R: reinforced insulation or double insulation

Review of IEC 61730-1:2016 (safety qualification)
Definitions

Insulation coordination

Pollution degree (PD)	Description (strongly dependent on module design and position in module)
1	No pollution or only dry, non-conductive pollution occurs, or additional requirements (IEC 61730-2, test sequence B1) are met.
2	Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.
3	Conductive pollution or dry non-conductive pollution occurs which becomes conductive due to condensation which is to be expected.

influences ▪ permitted clearance and creepage distances

Material groups (MG)	Description (dependent on used material with the least tendency to form a creepage path)
I	CTI > 600
II	400 ≤ CTI < 600
IIIa	175 ≤ CTI < 400
IIIb	100 ≤ CTI < 175

CTI = comparative tracking index acc. to IEC 60112

influences ▪ permitted clearance and creepage distances

Review of IEC 61730-1:2016 (safety qualification)
Requirements

The intended use, e.g., …

- as defined by the maximum system voltage
- for open-rack configurations only
- as BAPV – building attached PV
- as BIPV – building integrated PV
- in heavy snow condition areas (→ operating altitude)
- in increased temperature condition areas
- in marine applications
- in vehicle applications
- in agriculture applications
- etc.

…influences

- permitted clearance and creepage distances and distance through insulation
- individual test conditions: test voltage (MST 14, MST 16, MST 17), test temperature (MST 37, MST 56), requirements for installation (MST 21, MST 24)

…necessitates

- additional qualification standards (IEC 61701, IEC 62716, …)

Review of IEC 61730-1:2016 (safety qualification)
Requirements

Requirements for design and construction

Marking and documentation:

- name / registered trade name / trade mark of manufacturer
- module type designation
- serial number
- date and place of manufacture (alternatively: serial number assuring according traceability)
- polarity of terminals or leads
- maximum system voltage
- class of protection against electrical shock
- open-circuit voltage **with manufacturing tolerances**
- short-circuit current **with manufacturing tolerances**
- maximum output power with manufacturing tolerances
- maximum overcurrent protection rating
- all electrical data to be shown relative to STC
- international symbols to be used

Review of IEC 61730-1:2016 (safety qualification)
Requirements

Requirements for design and construction

Figure 1 – IEC 60417-5017

Figure 2 – IEC 60417-5021

Figure 3 – IEC 60417-5019

Marking and documentation:

- Symbols for equipotential bonding (Fig. 1 or Fig. 2)
- Symbol for functional earthing (Fig. 3)
- Documentation:
  - electrical and mechanical installation:
    - recommended maximum series / parallel PV module configurations
    - overcurrent protection rating
  - electrical ratings of the PV module:
    - as above (type label); in addition temperature coefficients (for Voc, Isc and Pmpp)
  - class and specific limitations
  - environmental conditions (min.: -40°C to +40°C, wind/snow load with safety factor)
  - appropriate documentation for safe installation, use and maintenance
  - advice not to expose PV modules to concentrated sunlight
  - statement for increased output:

"Under normal conditions, a photovoltaic module is likely to experience conditions that produce higher current and/or voltage than reported at standard test conditions. Accordingly, the values of *Isc* and *Voc* marked on this PV module should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor current ratings, and size of controls (e.g. inverter) connected to the PV output."

Review of IEC 61730-1:2016 (safety qualification)
Requirements

Requirements for design and construction

Electrical components:

- Junction boxes ➔ IEC 62790
- Cables ➔ EN 50618 (IEC 62930 under development)
- Connector ➔ IEC 62852

„Do not disconnect under load“

- Electrical insulation layers (backsheet, frontsheet):
  - classification to Material group (CTI)
  - fulfilment of requirements for insulation in thin layers
  - appropriate TI, RTE, (RTI) values

Materials:

- Polymeric materials ➔ appropriate TI, RTE, (RTI) values
  - flammability class minimum V-1 according to IEC 60695-11-10 (not applicable to insulation in thin layers → covered only by MST 24)
  - Ball pressure test according to IEC 60695-10-2 at 75°C (not applicable to insulation in thin layers)
  - **Ignitability test (MST 24)** in final application (laminated or PV module)
  - Peel test for proof of **cemented joints** (MST 35)
  - **Materials creep test (MST 37)**

Review of IEC 61730-1:2016 (safety qualification)
Requirements

Protection against electrical shock

Clearances (cl) and creepage distances (cr):

- Refer to table 3/4

Distance through insulation (dti):

- **Cemented joints**
  - test voltage (MST 16, MST 17): increased by factor 1.35
  - Peel test (MST3 5) or Lap shear strength test (MST 36) required
- **Thin layers (single or multi layer) – “back sheet”**
  - ***Single layer***
    - thickness according to table 3/4 line 1b)
    - appropriate TI, RTE, (RTI) values
    - dielectric strength for reinforced insulation
  - ***Multi layer***
    - sum of thicknesses according to table 3/4 line 1b)
    - appropriate TI, RTE, (RTI) value for each layer
    - dielectric strength for reinforced insulation of the entire multi layer sheet

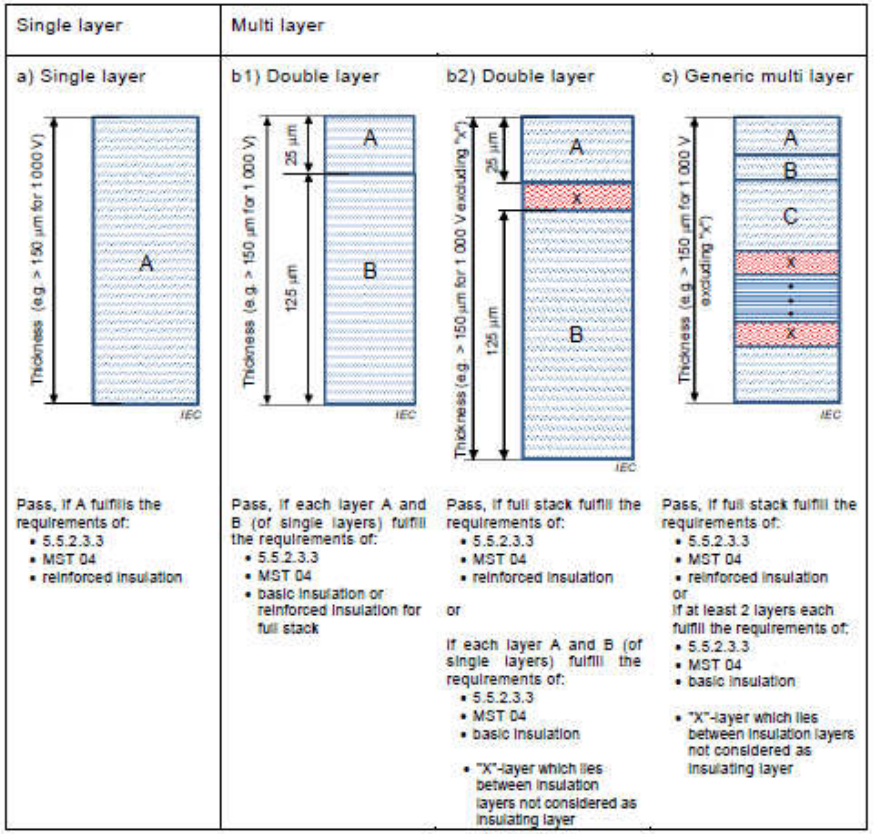
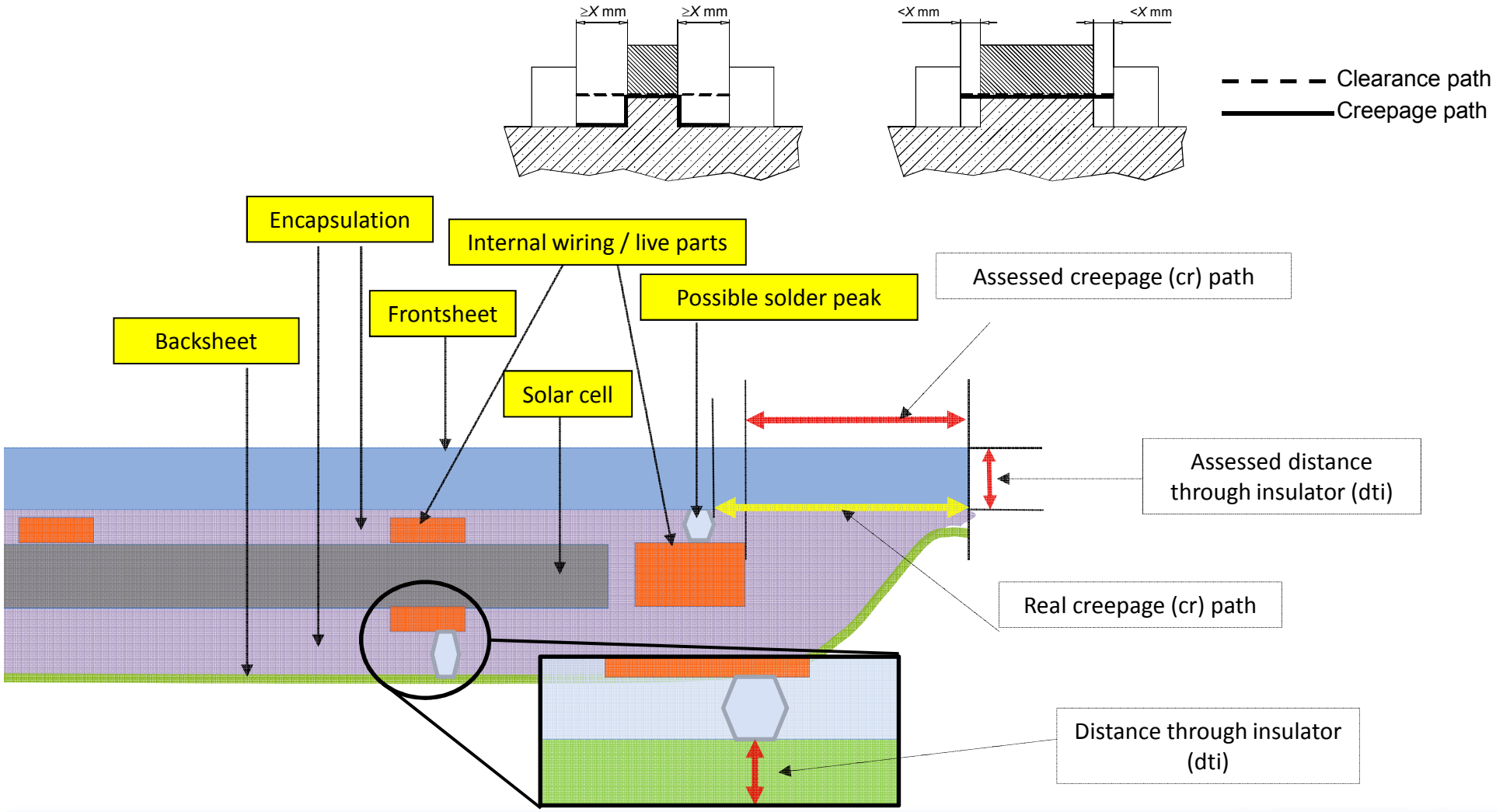


Figure 4 – Examples for individual layer assessment for relied upon insulation

Review of IEC 61730-1:2016 (safety qualification)

Creepage and clearance distances



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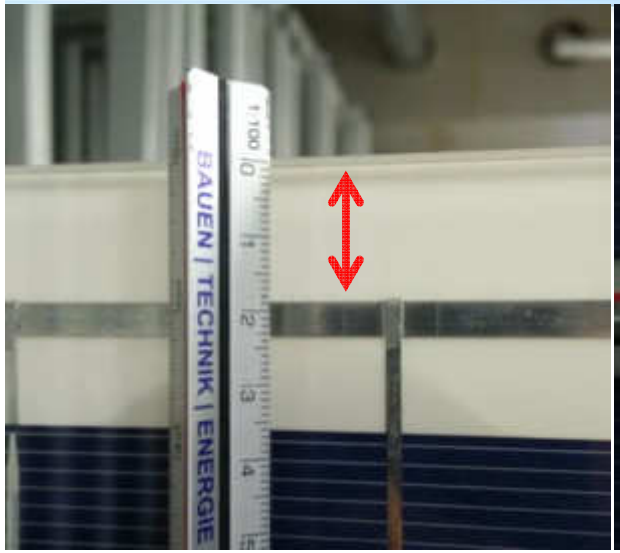
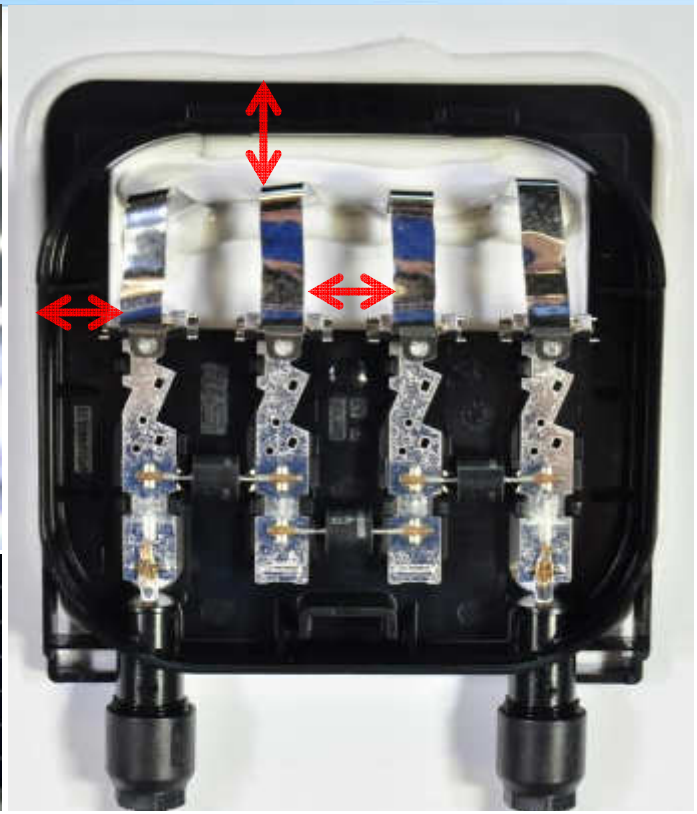
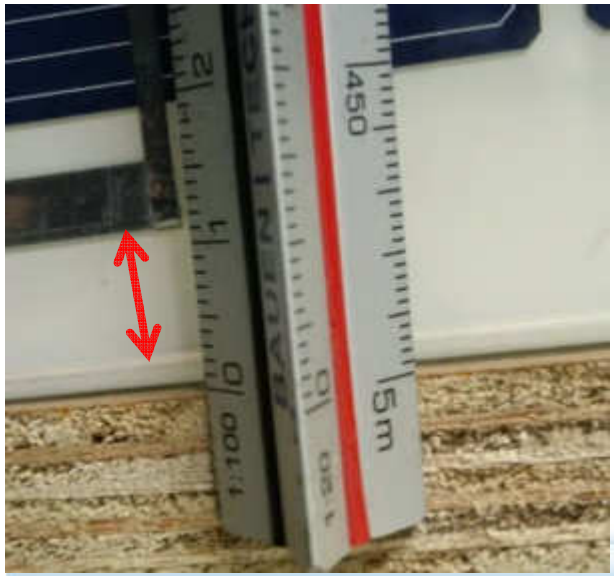
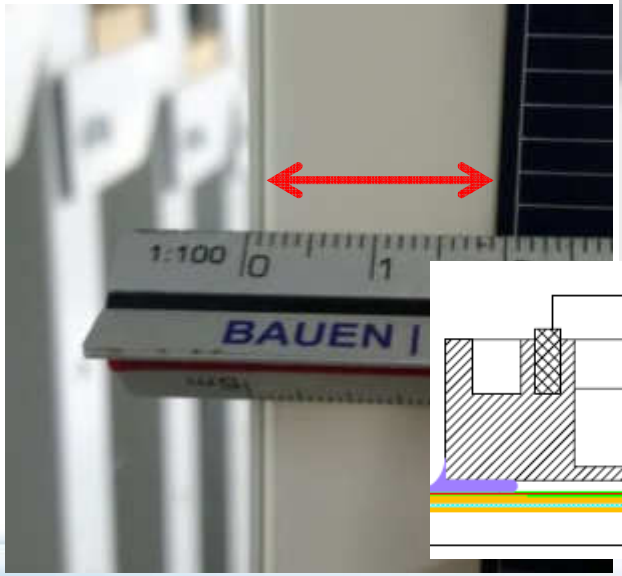
Review of IEC 61730-1:2016 (safety qualification)

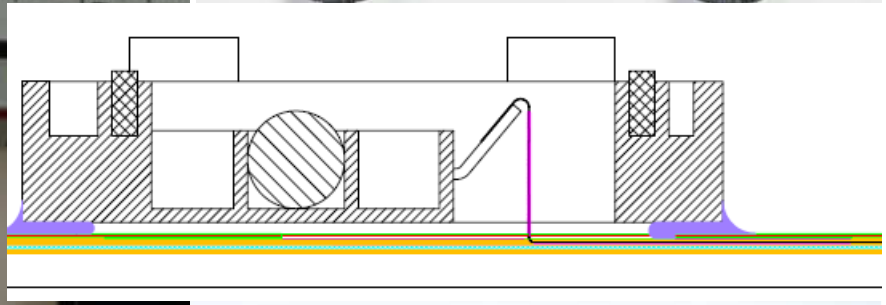
Creepage and clearance distances











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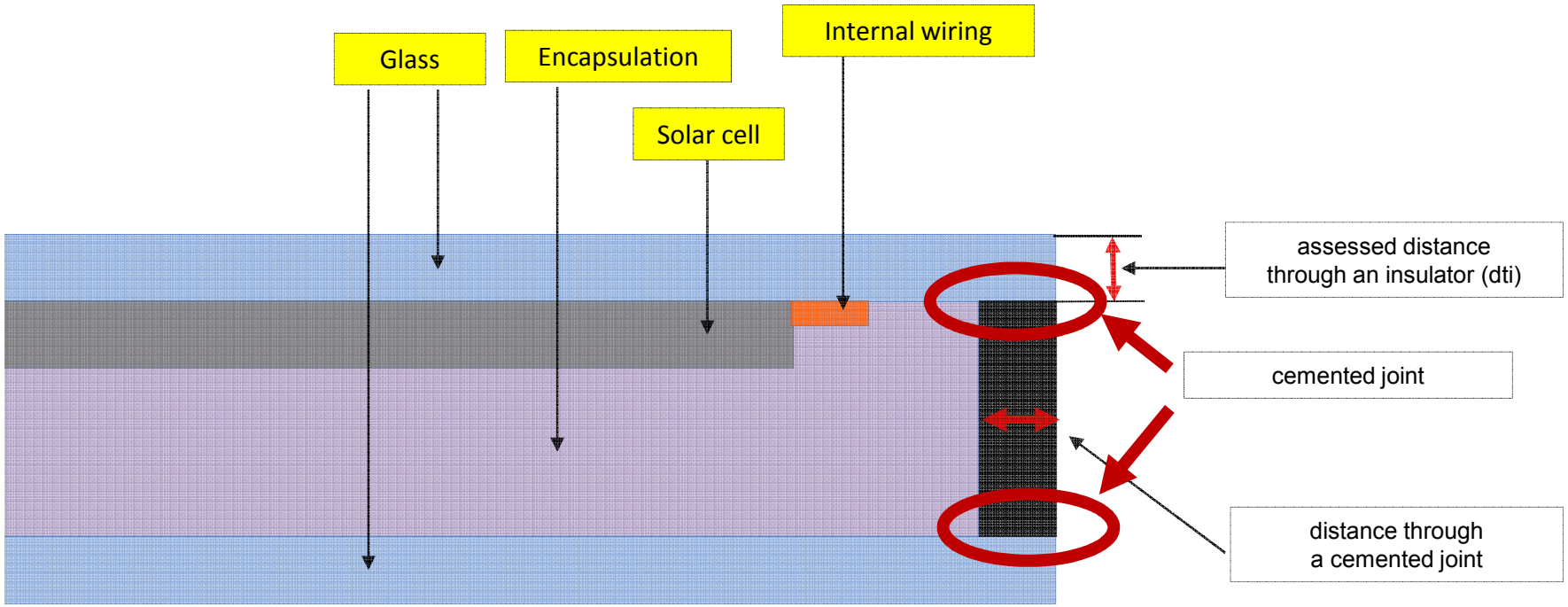
Review of IEC 61730-1:2016 (safety qualification)
Cemented joints

Insulation materials joint together by adhesion can be assessed as a sole insulator if the joint is durable and can be classified as a “cemented joint”.

A cemented joint can reduce minimum required edge distances.



Requirements for cemented joints:

a) no cracks or voids after any test **b)** 1.35 times higher test voltage in all tests

c) volume resistivity >50x10^6 Ωcm (dry) / >10x10^6 Ωcm (wet) **d)** Lap shear test / Peel test

Review of IEC 61730-1:2016 (safety qualification)

Comparison with previous standard

Example: System voltage = 1000 V	Edition 1	Edition 2	where to be found in Edition 2
Application Class / Class	Class A	II	Table 1
Thickness of an insulator (e.g. backsheet)	Not defined, limited by partial discharge test	150 µm	Table 3 and 4, 1b) thickness of thin layers
Clearance distance	8.4 mm (Table 4 in Edition 1)	14.0 mm	Table 3 and 4, 1a) conductive parts and outer surfaces
Creepage distance	Not defined and interpreted differently	6.4 mm for PD=1 10.0 mm for PD=2 and MG=I	Table 3 and 4, 1a) conductive parts and accessible surfaces

Review of IEC 61730-1:2016 (safety qualification)

Table 3 – Distances through insulation, creepage distances (cr) and clearances (cl) for Class II PV modules

Between	pollution degree	Distances in mm																							
		≤35 V DC [a,d]				100 V DC [a]				150 V DC [a]				300 V DC [a]				600 V DC [a]				1 000 V DC [a]				1 500 V DC [a]			
		cl	cr			cl	cr			cl	cr			cl	cr			cl	cr			cl	cr			cl	cr		
			Material group				Material group				Material group				Material group				Material group				Material group				Material group		
			I	II	III		I	II	III		I	II	III		I	II	III		I	II	III		I	II	III		I	II	III
1a) Internal live parts and outer accessible surfaces	1	0,5 [b, c]	0,4			1,5 [b]	0,5			3,0 [b]	0,6			5,5 [b]	1,4			8,0 [b]	3,4			14,0 [b]	6,4			19,4 [b]	10,4		
	2		1,2	1,7	2,4		1,4	2,0	2,8		1,6	2,2	3,1		3,0	4,2	6,0		6,1	8,6	12,0		10,0	14,2	20,0		15,0	20,8	30,0
	3		3,0	3,4	3,8		3,6	4,0	4,4		3,9	4,3	4,9		7,5	8,5	9,4		15,2	17,1	19,1		25,0	28,0	32,0		37,7	41,7	47,1
1b) Thickness of thin layers (see 5.6.4.3)	-	0,01				0,01				0,01				0,01				0,06				0,15				0,3			
2) Live parts of different potential inside a PV module	1	0,1	0,2			0,5 [b, c]	0,3			1,5 [b]	0,3			3,0 [b]	0,7			5,5 [b]	1,7			8,0 [b]	3,2			11,0 [b]	5,2		
	2	0,2	0,6	1,0	1,2		0,7	1,0	1,4		0,8	1,1	1,6		1,5	2,1	3,0		3,0	4,3	6,0		5,0	7,1	10,0		7,5	10,4	15,0
	3	0,8	1,5	1,7	1,9		1,8	2,0	2,2		2,0	2,2	2,5		3,8	4,2	4,7		7,6	8,6	9,5		12,5	14,0	16,0		18,9	20,9	23,6
3) Terminals of different polarity of rewireable junction boxes	1	0,5 [b, c]	0,4			1,5 [b]	0,5			3,0 [b]	0,6			5,5 [b]	1,4			8,0 [b]	3,4			14,0 [b]	6,4			19,4 [b]	10,4		
	2		1,2	1,7	2,4		1,4	2,0	2,8		1,6	2,2	3,1		3,0	4,2	6,0		6,1	8,6	12,0		10,0	14,2	20,0		15,0	20,8	30,0
	3		3,0	3,4	3,8		3,6	4,0	4,4		3,9	4,3	4,9		7,5	8,5	9,4		15,2	17,1	19,1		25,0	28,0	32,0		37,7	41,7	47,1
4) Distance through cemented joints	-	0,2				0,3				0,5				1,0				1,5				2,0				3,5			

[a] For lines 1a), 1b), 3) and 4) the relevant voltage which is applicable shall be the system voltage. For line 2) the working voltage between parts of different potential at STC is relevant. All values given in this table are rounded to one digit from IEC 60664-1.

[b] If a measured clearance is smaller than the minimum required clearance an impulse voltage test as specified in IEC 60664-1shall show that the distance is adequate. To assess clearances between internal live parts and outer accessible surfaces IEC 61730-2, MST 14 may be applied.

[c] This value is increased to 0,8 mm for pollution degree 3.

[d] For designs where working voltage is below 20 V values directly from IEC 60664-1 can be applied

Content

- Basic understanding of the recent modifications of the IEC guidelines for PV modules
- Review of IEC 61215:2016 (type approval) - general requirements and test methods
- Review of IEC 61730-1:2016 (safety qualification) - requirements for construction
- Review of IEC 61730-2:2016 (safety qualification) - requirements for testing
- Transitional periods
- Closing remarks

Review of IEC 61730-2:2016 (safety qualification)

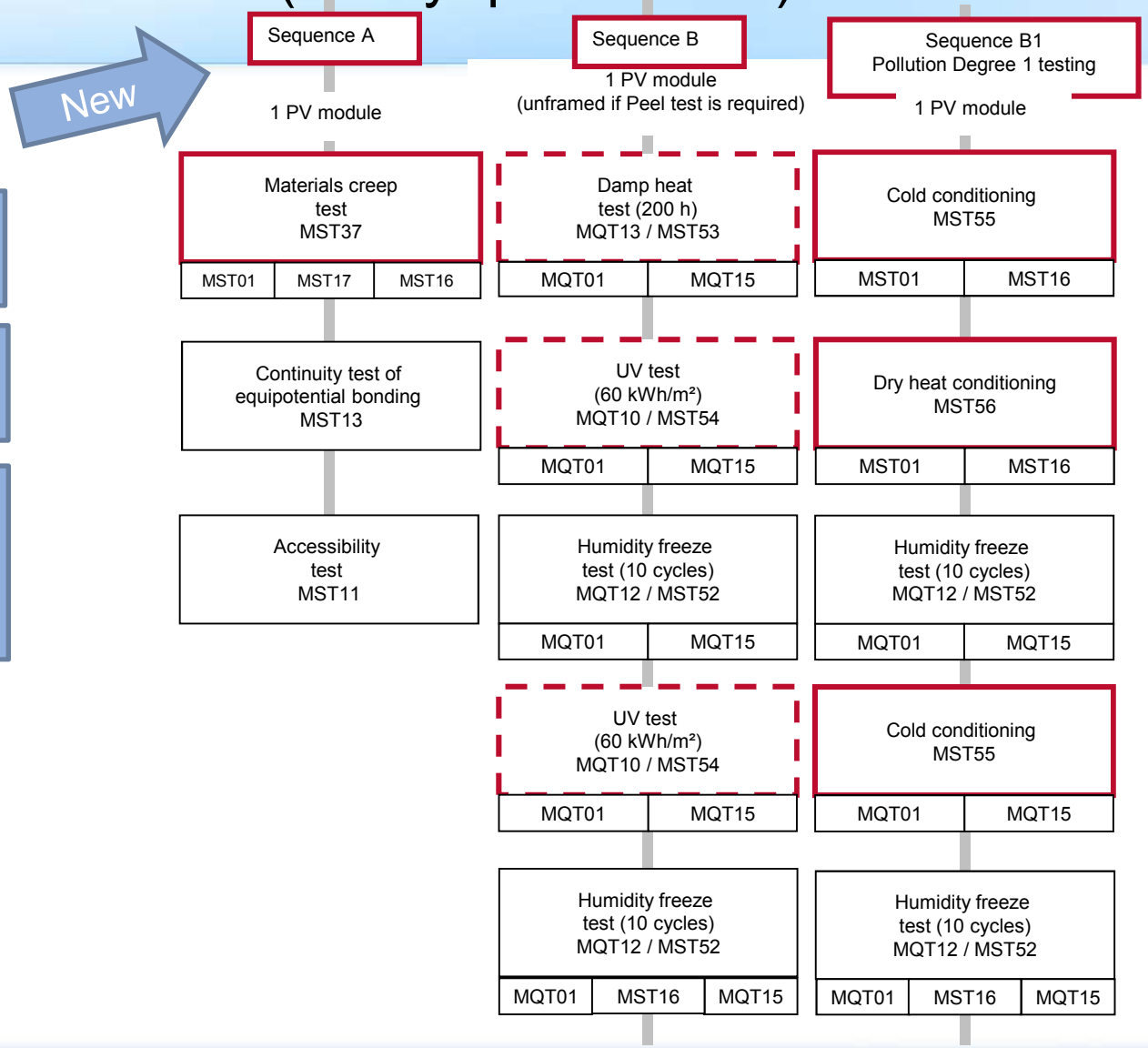
- Combined test chart

New sequences

New tests

Extended requirements of individual tests and combination of tests in a sequence

Adapted or new test methods



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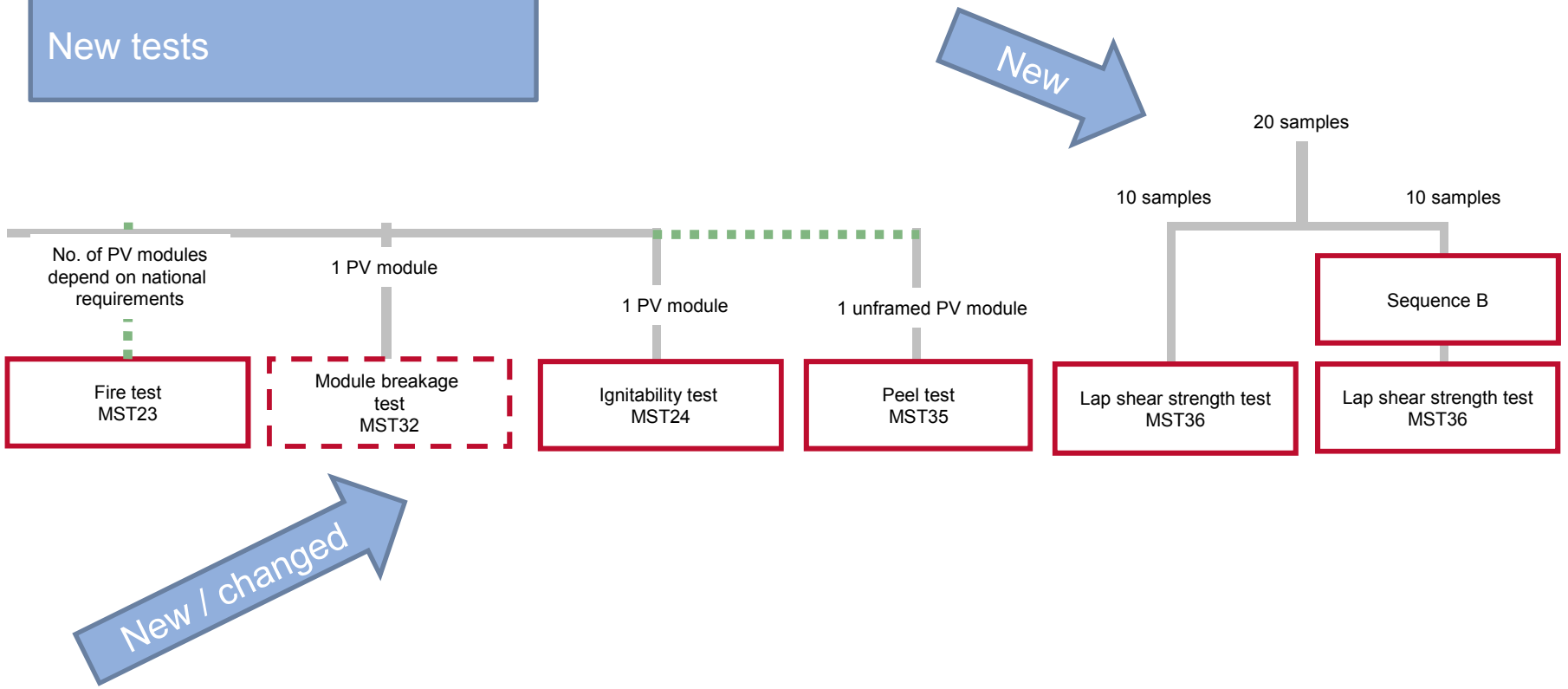
Review of IEC 61730-2:2016 (safety qualification)

Minor or major changes in test procedures

New tests



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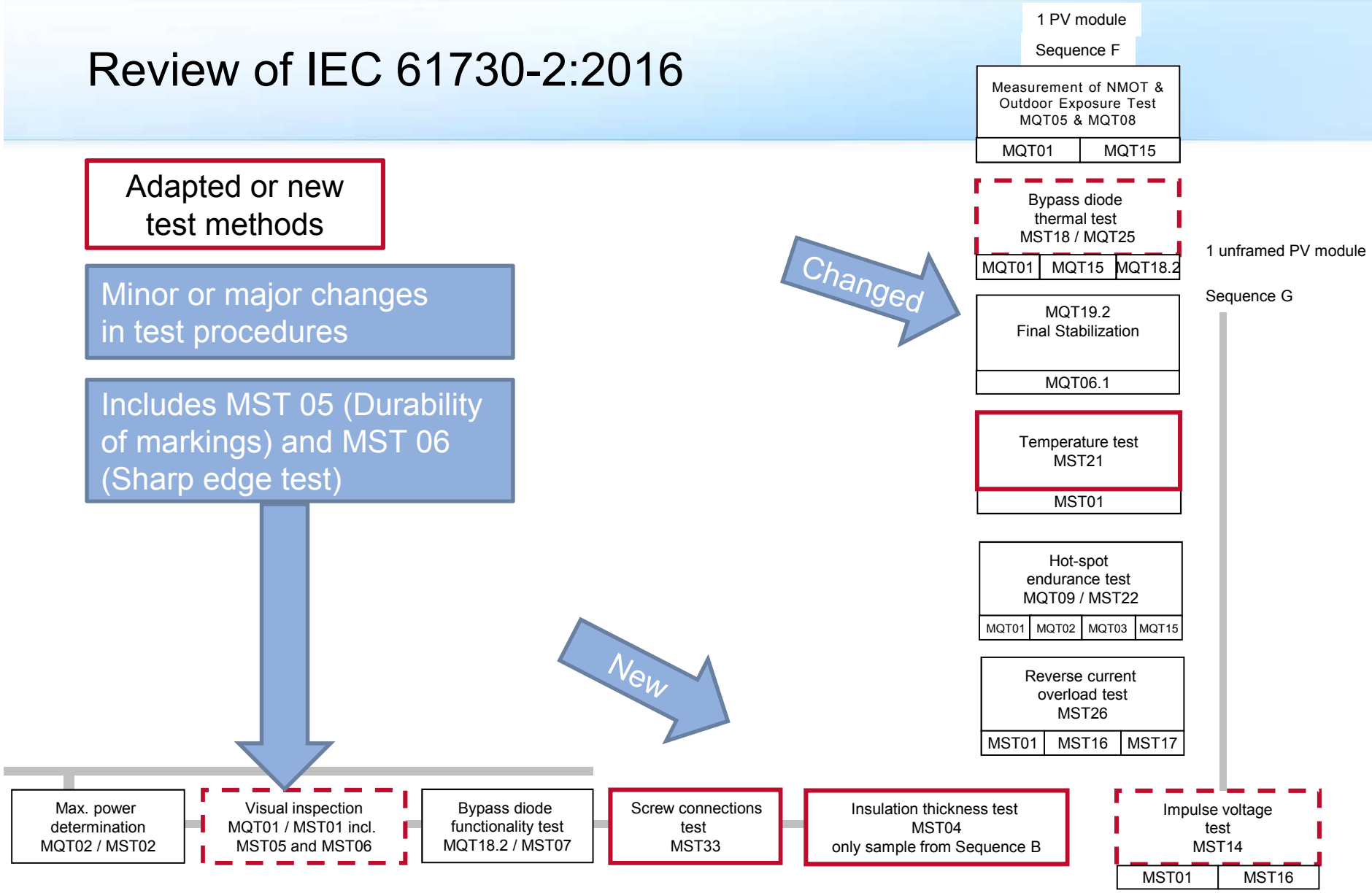
Review of IEC 61730-2:2016



Review of IEC 61730-2:2016 (safety qualification)

MST 01 – Visual inspection

- Purpose: Detection of any visual defects and changes in the module
- As MQT 01 of IEC 61215-2, but with additional major visual defects defined:

- in cemented joints bubbles or delaminations with closest distances to each other ≤ 2 times the minimum required distance through cemented joint

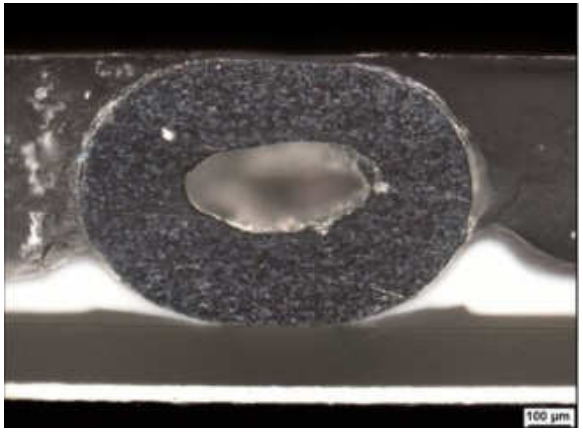
  → evaluated as conductive and electrically connected

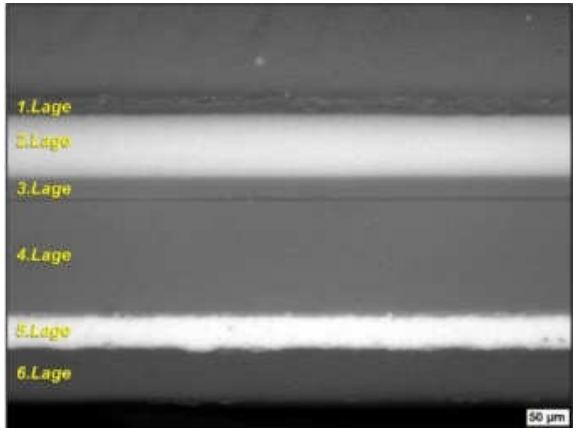
- markings not complying with demands on contents and with Durability of markings test
- edges not complying with Sharp edge test

Review of IEC 61730-2:2016 (safety qualification)

MST 04 – Insulation thickness test

- New requirement
- Purpose: Determination of layer thicknesses in order to verify the minimum insulation thickness for thin layers acc. to table 3+4, IEC 61730-1
- Only applicable for *polymeric* insulation layers
- Performed after environmental test sequence B
- Three samples per module side chosen for measurement (to be representative for min. insulation thickness, e.g., soldering joints, edge of laminate …)
- Requirement: minimum insulation thickness acc. to table 3+4, IEC 61730-1

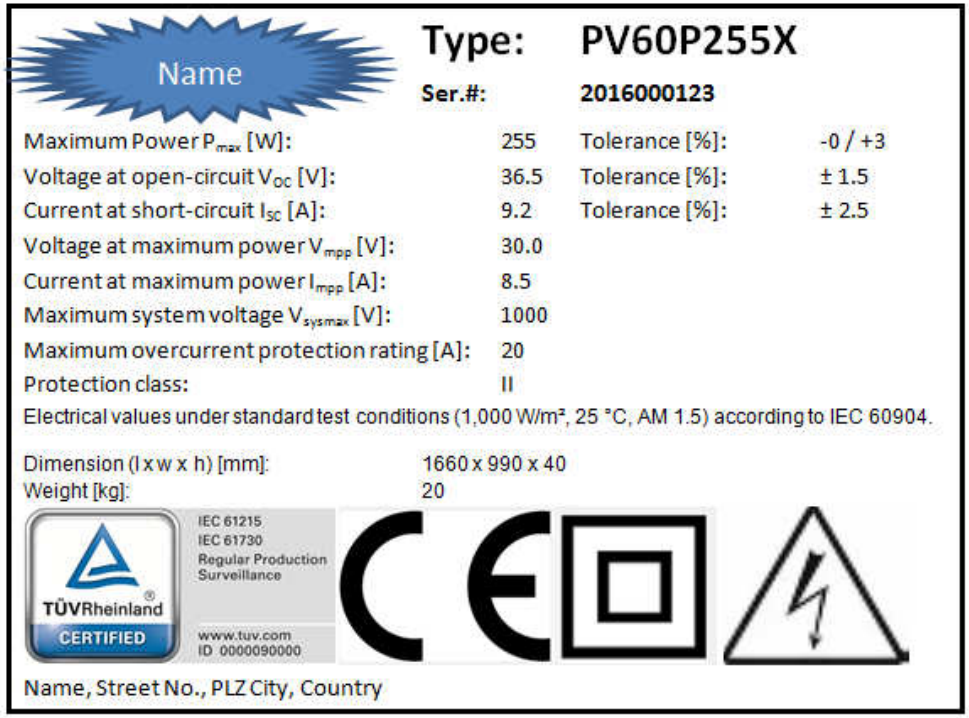




Review of IEC 61730-2:2016 (safety qualification)

MST 05 – Durability of markings

- New requirement
- Purpose: Label shall be durable and legible also after stress and climate chamber testing
- Marking rubbed after pre-conditioning for 15 s by hand using
  - Cloth soaked with water
  - Cloth soaked with petroleum spirits
- Control testing on one test sample from each sequence



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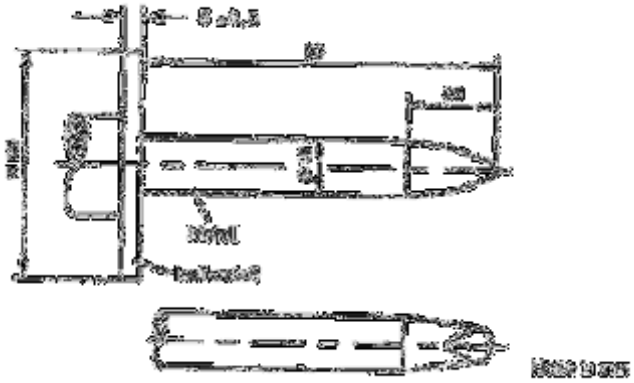
MST 06 – Sharp edge test

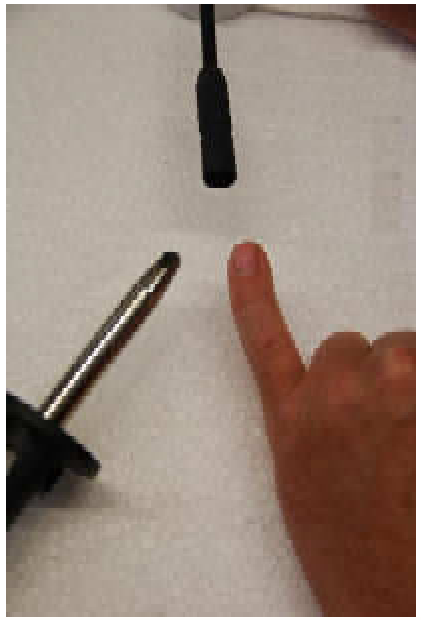
- New requirement (equivalent to ANSI/UL 1703 sharp edge test)
- Purpose: Accessible module surface shall be smooth and free from sharp edges, burrs, etc. which may damage the insulation of conductors or pose a risk of injury
- Compliance checked with sharp edge tester

Review of IEC 61730-2:2016 (safety qualification)

MST 11 – Accessibility test

- No changes
- Purpose: Investigation if adequate protection against accessibility to hazardous live parts (> 35 V)
- Apparatus: Cylindrical test fixture and ohmmeter or continuity tester
- Pass criteria: At no time during test resistance of less than 1 MΩ between test fixture and PV module live parts

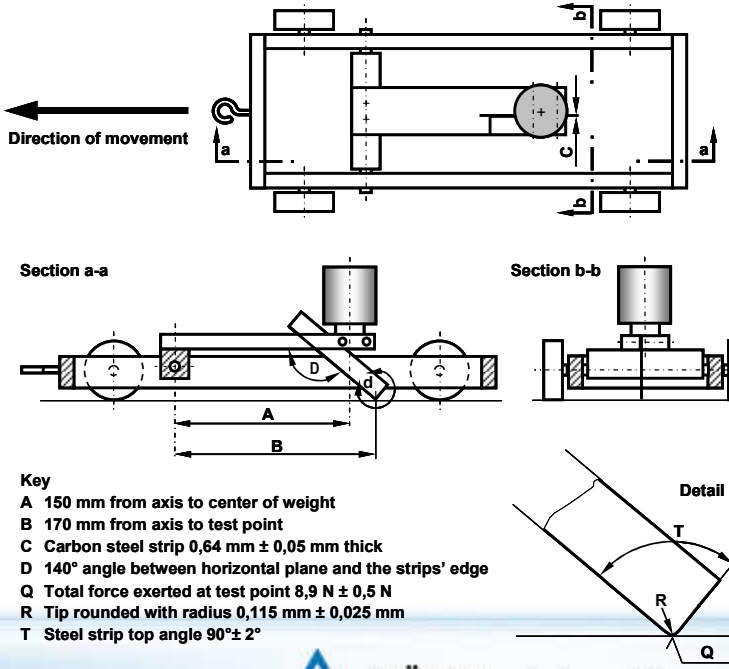




Review of IEC 61730-2:2016 (safety qualification)

MST 12 – Cut susceptibility test

- No changes
- Purpose: Determination whether any polymeric front / rear surfaces of the module can withstand routine handling during installation and maintenance without causing risk of electric shock.
- Not applicable to rigid-to-rigid bonded assemblies (e.g. glass/glass PV modules)
- Performed after chamber tests
- Test fixture placed on surface for 1 min and then drawn across the surface of the PV module with 150 mm/s ± 30 mm/s. Repeated five times in different directions.
- Control measurements:
  - MST 01 (Visual inspection)
  - MST 16 (Insulation test)
  - MST 17 (Wet leakage current test)



Key
A 150 mm from axis to center of weight
B 170 mm from axis to test point
C Carbon steel strip 0,64 mm ± 0,05 mm thick
D 140° angle between horizontal plane and the strips' edge
Q Total force exerted at test point 8,9 N ± 0,5 N
R Tip rounded with radius 0,115 mm ± 0,025 mm
T Steel strip top angle 90°± 2°

Review of IEC 61730-2:2016 (safety qualification)

MST 13 – Continuity test of equipotential bonding

- Former *Ground continuity test*, minor changes
- Purpose: To demonstrate that there is a conductive path between all exposed conductive surfaces of the PV module, so that the exposed conductive surfaces can be adequately grounded in a PV system
- Test conditions:
  - current of 2.5 * maximum overcurrent protection rating (± 10 %) applied
  - time: 2 min
- All other frame parts tested

Review of IEC 61730-2:2016 (safety qualification)

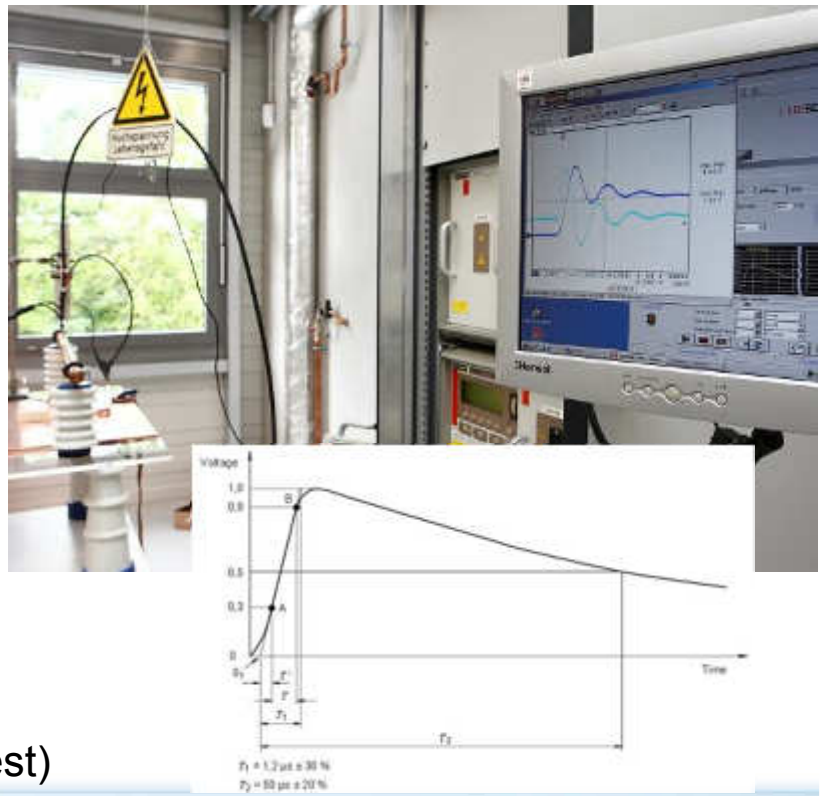
MST 14 – Impulse voltage test

- Major changes
- Purpose: To verify capability of module insulation to withstand atmospheric over-voltages
- Test performed with unframed PV module. If frame integral part of the edge insulation, framed module is acceptable.
- No preconditioning (TC 200)
- Test voltage according to table B.1:

Table B.1 – Rated impulse voltage

Rated voltage V a.c.	Values for the rated impulse voltage for basic insulation [illegible]	Values for the rated impulse voltage for double or reinforced insulation [illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

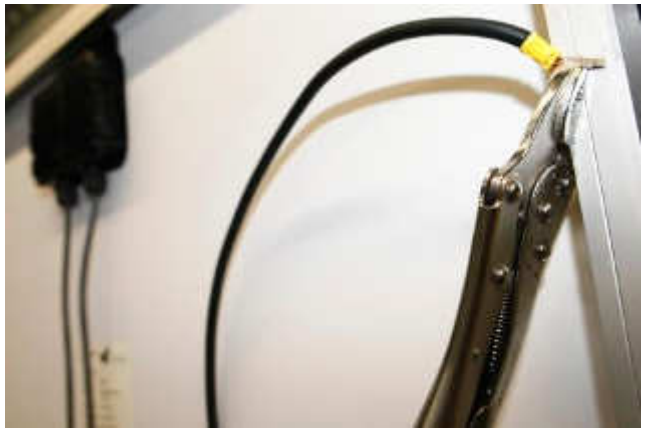


- Control measurements:
  - MST 01 (Visual inspection), MST 16 (Insulation test)

Review of IEC 61730-2:2016 (safety qualification)

MST 16 – Insulation test

- As MQT 03 with increased test voltage:
  - V_{test} = 4 x V_{MaxSys} + 2000 V_{DC}
- Test voltage depending on Class
- New: Higher test voltage for „cemented joints“
  - V_{test} = (4 x V_{MaxSys} + 2000 V_{DC}) x 1.35
  - Maximum possible V_{test} = (4 x 1500 V_{DC} + 2000 V_{DC}) x 1.35 = **10800 V_{DC}**



Review of IEC 61730-2:2016 (safety qualification)

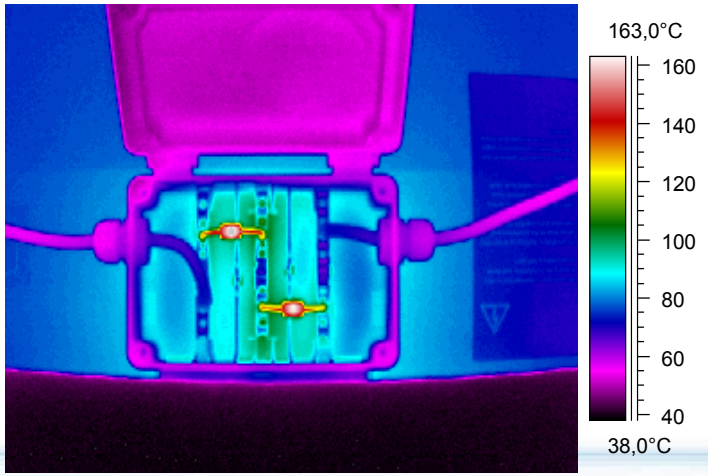
MST 17 – Wet leakage current test

- As MQT 15
- New: Higher test voltage for „cemented joints“
  - $V_{test} = V_{MaxSys}$ x 1.35
  - Maximum possible V_{test} = 1500 V_{DC} x 1.35 = **2025 V_{DC}**

Review of IEC 61730-2:2016 (safety qualification)

MST 21 – Temperature test

- Major changes
- Purpose: To determine maximum reference temperatures for all module components and materials in order to verify suitability of usage
- Indoor and outdoor method are possible; indoor preferred
- Material specific values “RTI, RTE or TI” needed; to be provided by manufacturer
- Only one test cycle near maximum power point
- Sub-structure considered: PV module to be mounted
  - above a black platform in acc. with the installation instructions
  - directly on a black platform, if no indications for spacing given by manufacturer
- Control measurements:
  - MST 01 (Visual inspection)
  - MST 16 (Insulation test)
  - MST 17 (Wet leakage current test)



Review of IEC 61730-2:2016 (safety qualification)

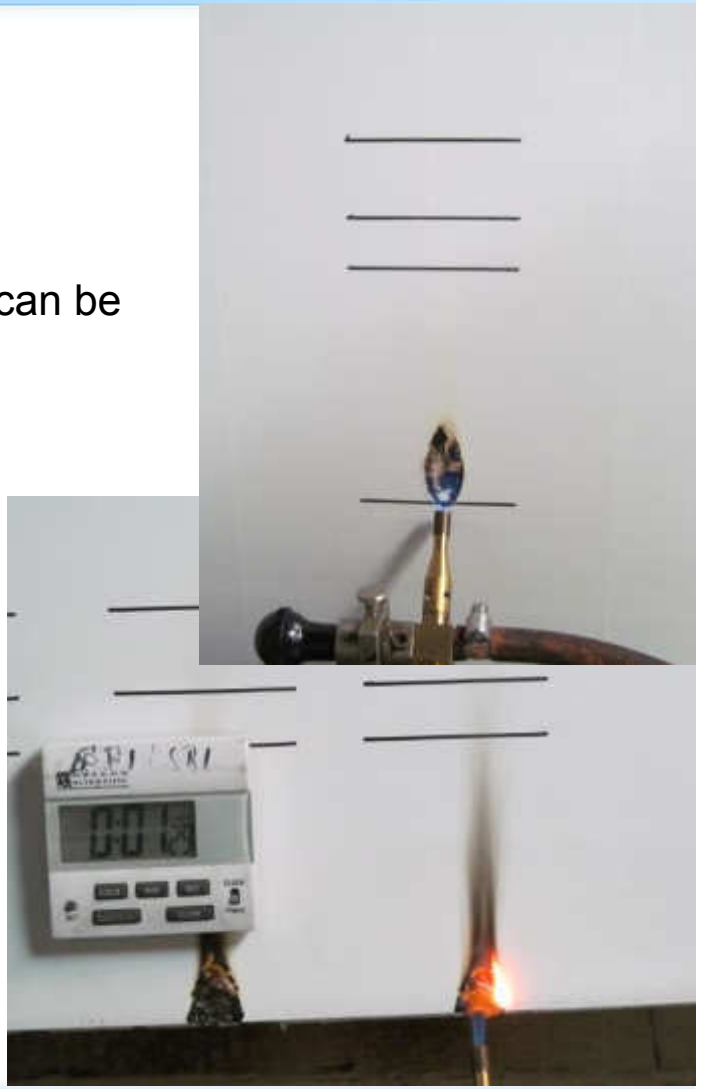
MST 23 – Fire test

- Not mandatory anymore
- No harmonized international requirement for fire safety
- Reference to national and regional guidelines, annexes and/or building codes, e.g.:
  - ISO 934-1, ISO 834-3
  - ISO 5657
  - ISO 13501-5
  - ENV 1187-1/-2/-3/-4
  - ANSI/UL 790

Review of IEC 61730-2:2016 (safety qualification)

MST 24 – Ignitability test

- New requirement
- Purpose: Evaluation of ignitability of outer module layers
- Based on ISO 11925-2 (if acc. approval can be shown, test can be omitted)
  - one module per type family selected (without pre-stress)
  - test conditions: 23°C ± 5°C, 50 % ± 20 %, defined max. air speed 5 cm from the surface
    (pre-conditioning: 48 h at 23°C / 50 %)
  - gas burner with specific mounting and mobility applied to defined module positions (each for 15 s)
  - Polymerics applied for this test; electrical components (junction box etc.), glass, metal not to be tested
  - pass/fail criterions: ignitability, maximum flame height, length of destroyed area

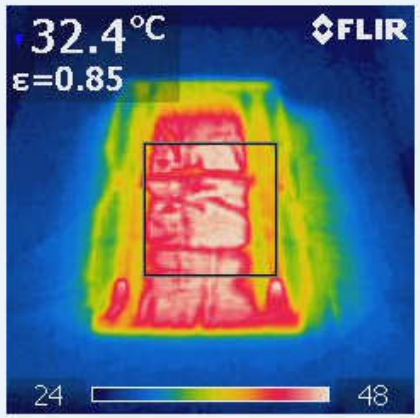


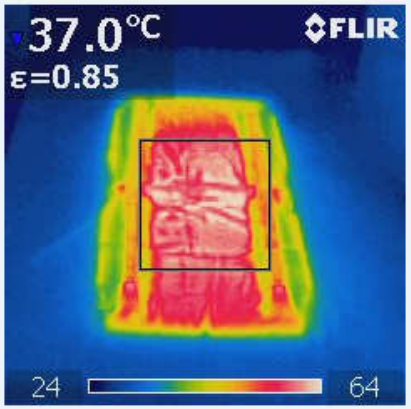
Review of IEC 61730-2:2016 (safety qualification)

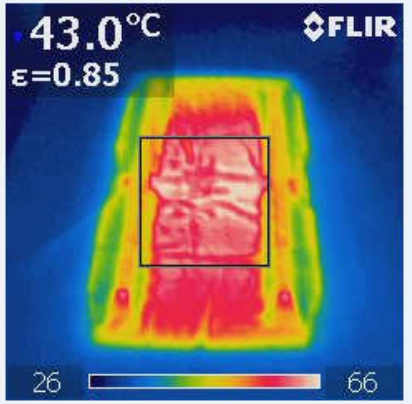
MST 26 – Reverse current test

- Minor changes (specifications for test equipment)
- Purpose: To determine the risk of ignition or fire under reverse current fault conditions
- A reverse current can be applied also for warming up the modules in alpine region
- Test conditions:
  - current of 1.35 x maximum overcurrent protection rating applied
  - time: 2 h
- Control measurements:

  MST 01 (Visual inspection), MST 16 (Insulation test), MST 17 (Wet leakage current test)







Review of IEC 61730-2:2016 (safety qualification)

MST 32 – Module breakage test

- Minor changes
- Purpose: To verify that the risk of physical injuries can be minimized in case module is broken in installation
- Test procedure reduced to only one impact from one height: **300 mm** (450 mm and 1220 mm impacts not applied anymore)
- Minor modification of pass criteria:

  1. No separation from mounting structure or frame

  and

  2. either

  a) no breakage occurs

  or

  b) breakage occurs, but no shear or opening larger than 76 mm diameter develops *and* no particles larger than 65 cm² ejected from test sample

- Control measurements:

  MST 01 (Visual inspection), MST 13 (Continuity test of equipotential bonding)

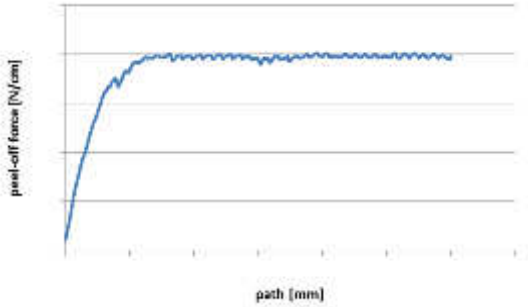
Review of IEC 61730-2:2016 (safety qualification)

MST 33 – Screw connections test

- New requirement
- Purpose: To verify long-life cycle of screws and nuts used in a module
- Components like screws and nuts transmitting contact pressure or likely to be tightened by the user are to be tightened and loosened five times. Screws and nuts of insulating material are to be removed completely during each screws loosening operation.
- Pass criteria:
  - No damage impairing the further use of the fixing or screwed connection
  - After the test, it shall still be possible to use the screw or nut made of insulation material in the intended manner.

Review of IEC 61730-2:2016 (safety qualification)

MST 35 – Peel test



- New optional test
- Purpose: Qualification of an insulation as cemented joint
- Allowed clearance and creepage distances can significantly be reduced
- Only relevant for rigid to flexible or flexible to flexible designs
- Two test samples required (one preconditioned by Sequence B)

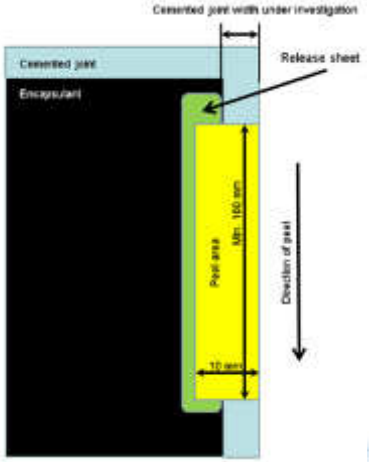
→ may be combined with Sequence B testing incl. qualification requirements

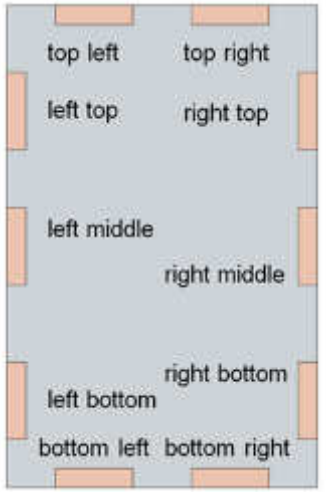
- Ten strips to be cut out of sample; performance of peel test acc. to ISO 23529
  - 5 test samples: cemented joint to flexible sheet
  - 5 test samples: cemented joint to rigid sheet
  - Comparison of results:

$$\frac{\sum_1^{10} M2}{\sum_1^{10} M1} > 0.5$$

M1: breaking force for unconditioned samples

M2: breaking force for conditioned samples





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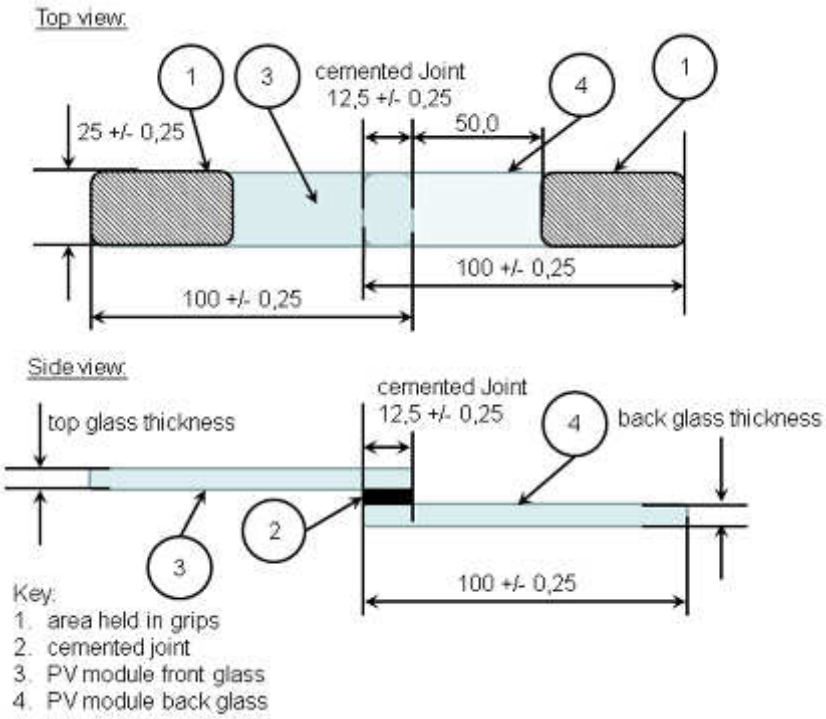
MST 36 – Lap shear strength test

- New optional test
- Purpose: Qualification of an insulation as cemented joint
- Allowed clearance and creepage distances can significantly be reduced
- Only relevant for rigid to rigid designs
- 20 test samples required acc. to ISO 4587:2003
  - 10 test samples go through Sequence B
  - 10 test samples without preconditioning
  - Measurement of breaking force M during rupture
  - Comparison of results:

$$\frac{\sum_1^{10} M2}{\sum_1^{10} M1} > 0.5$$

M1: breaking force for unconditioned samples

M2: breaking force for conditioned samples



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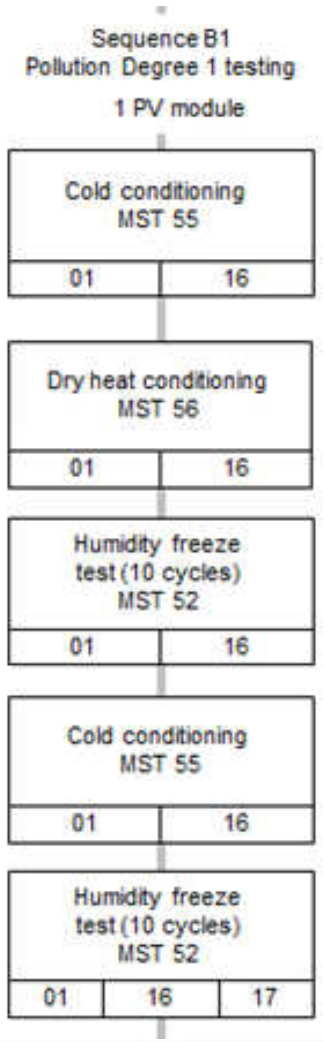
MST 37 – Materials creep test

- New requirement
- Purpose: Verification that materials used in module will not show creep or lose adhesion during high operation temperatures in the field (frontsheet-backsheet, backsheet-JB / -back rail…)
- Not applicable if creep at all interfaces prevented by mechanical mounting means
- Modules tested in environmental chamber with worst-case mounting and max. angle
- Test conditions: 105°C ± 5°C, dry, for 200 h (for module types for pure open rack configuration: 90°C ± 3°C)
- Control measurements:
  - MST 01 (Visual inspection)
  - MST 11 (Accessibility test)
  - MST 13 (Continuity test of equipotential bonding)
  - MST 16 (Insulation test)
  - MST 17 (Wet leakage current test)
  - Check of creepage and clearance distances acc. to table 3 or 4 of IEC 61730-1

Review of IEC 61730-2:2016 (safety qualification)

Sequence B1

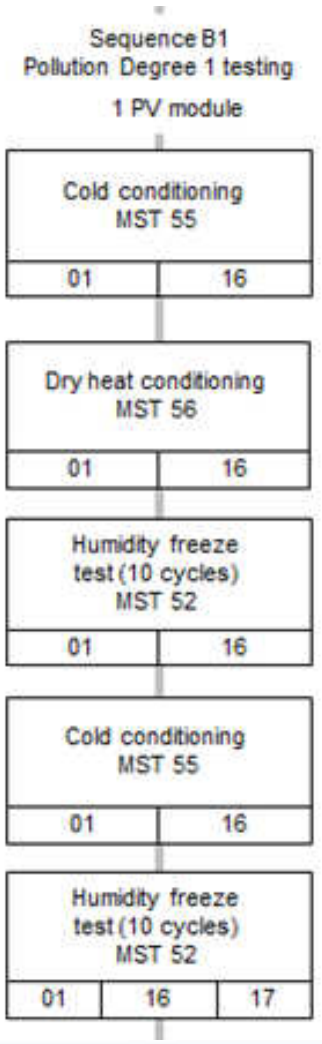
- New optional test sequence
  (required for extension to Pollution degree 1)
- One module tested
- Can be combined with Sequence A
- New tests included:
  - MST 55 (Cold conditioning)
  - MST 56 (Dry heat conditioning)



Review of IEC 61730-2:2016 (safety qualification)

MST 55 – Cold conditioning

- New climate chamber test
- Relevant in Sequence B1 (Pollution degree 1)
- Test conditions:
  - Temperature: -40°C ± 3°C
  - Time: 48 h
- Control measurements:
  - MST 01 (Visual inspection)
  - MST 16 (Insulation test)



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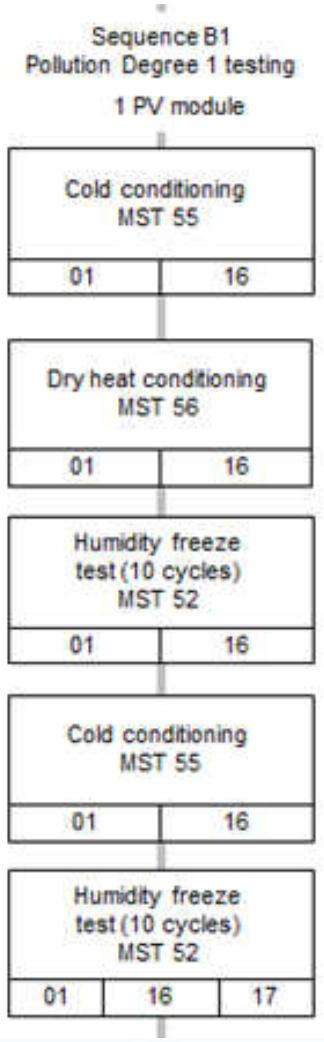
MST 56 – Dry heat conditioning

- New climate chamber test
- Relevant in Sequence B1 (Pollution degree 1) and for MST 37 (Material creep test)
- Test conditions:
  - Temperature: 105 °C ± 5°C (for module types for pure open rack configuration: 90°C ± 3°C)
  - r.H. ≤ 50%
  - Time: 200 h
- Control measurements
  - MST 01 (Visual inspection)
  - MST 16 (Insulation test)



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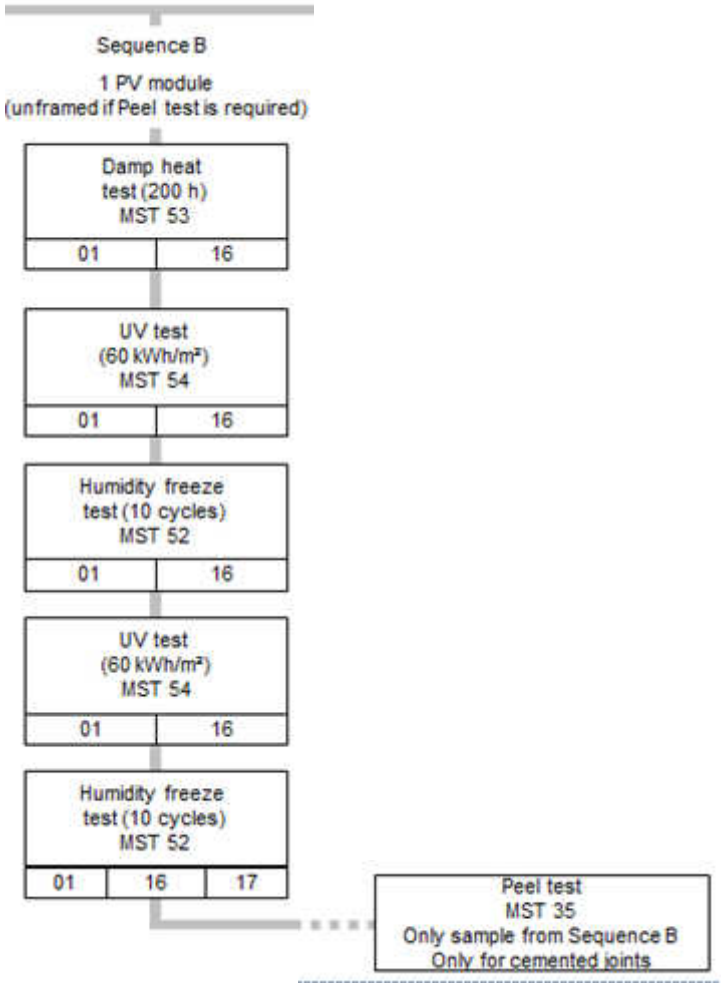
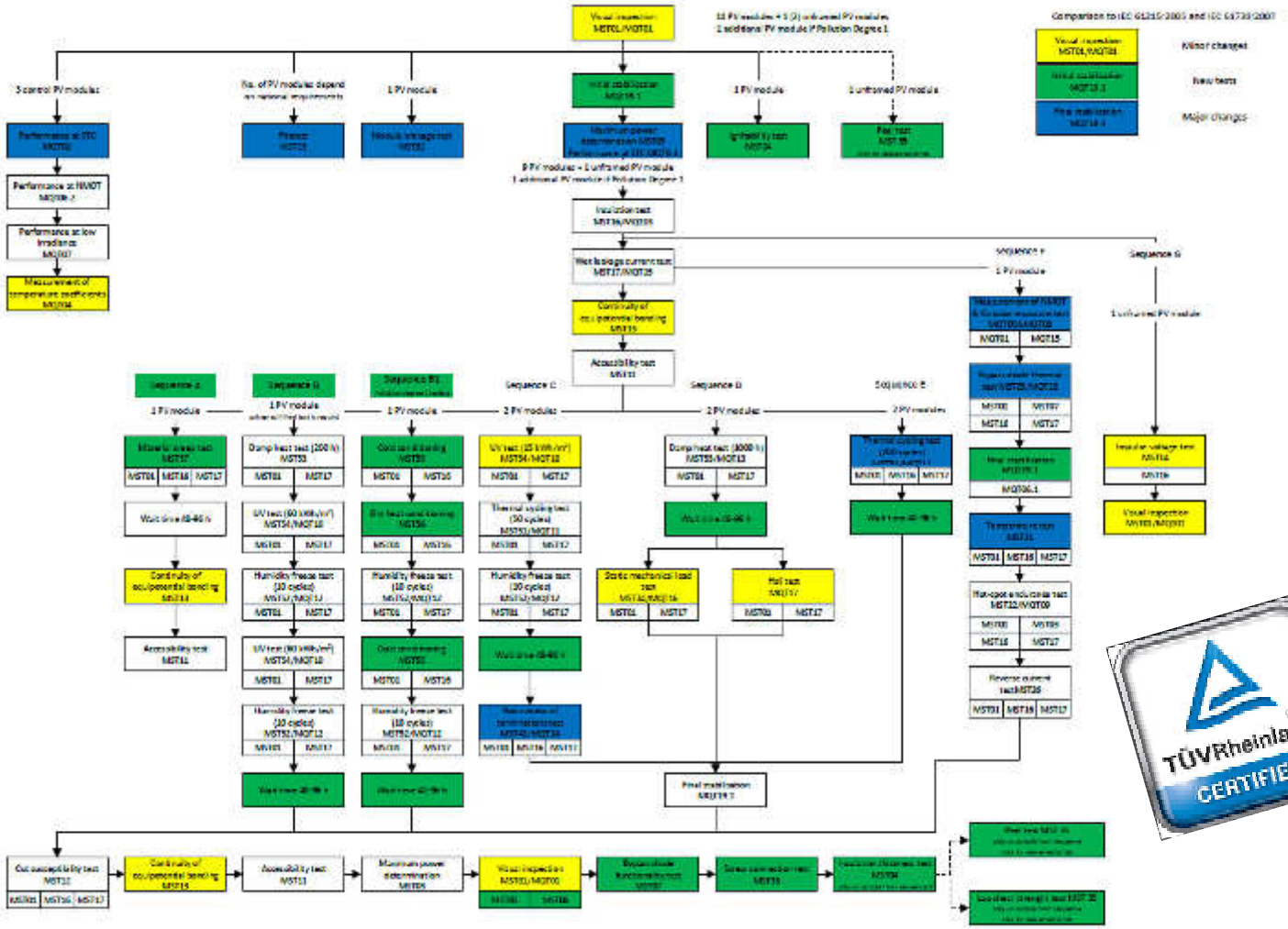
Sequence B

- New mandatory test sequence
- One module used
- Cycling aging of UV and HF with additional DH
- Increased UV irradiation; exposure from front and from back side
- Also used as pre-conditioning for
  - MST 35 (Peel test)
  - MST 36 (Lap shear strength test)
- For Peel test laminate required



IEC 61215 & 61730:2016 combined testing tree



Qualification of

- one design
- one power range
- 15 test samples
- duration 4 - 5 months

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Content

Transitional periods

- No defined date of withdrawal (DOW) for IEC 61215:2005 and IEC 61646:2008
- Also no DOW for IEC 61730:2004, however generally considered not to be acc. to state of the art for PV modules
- New EN 61730:20XX will probably appear mid of 2017
- No active withdrawal of IEC 61730:2004 certificates, but presumably max. 12 months after publication of new EN 61730
- **TÜV Rheinland entities agreed that from March 2017 for new basic certification applications the new IEC61215:2016 and IEC61730:2016 will be offered only**

Content

Closing remarks

- IEC 61215-1, -1-1 and -2 were published in March 2016.
- IEC 61215-1-2, 1-3 and 1-4 were published in December 2016.
- IEC 61730-1 and -2 were published in August 2016.
- EN 61730 publication is expected in the next months without any modifications.
- North America has formed a committee for the harmonization of ANSI/UL 1703 and IEC 61730; aim: ANSI 61730.
- Retesting in case of design or material changes are regulated in IEC TS 62915 (former IECEE Retesting Guideline).
- Pollution Degree 1 testing acc. to IEC 61730-1 sequence B1 may enable reduced edge distances and makes Material Groups irrelevant for these.
- Material Group I requires a CTI $\geq$ 600 from all materials that may form a creepage path surface. Material Group I may allow smaller edge distances even for higher Pollution Degrees.
- Cemented joints are a valid solution for any design to reduce edge distances.
- Generally, new standards provide a large number of options for manufacturers in order to expose its design on the market, but require detailed design review in advance and pre-information to be supplied for test institute.

Questions?

For more clarity:

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