# 複合加速試験に許容される試験費用推定

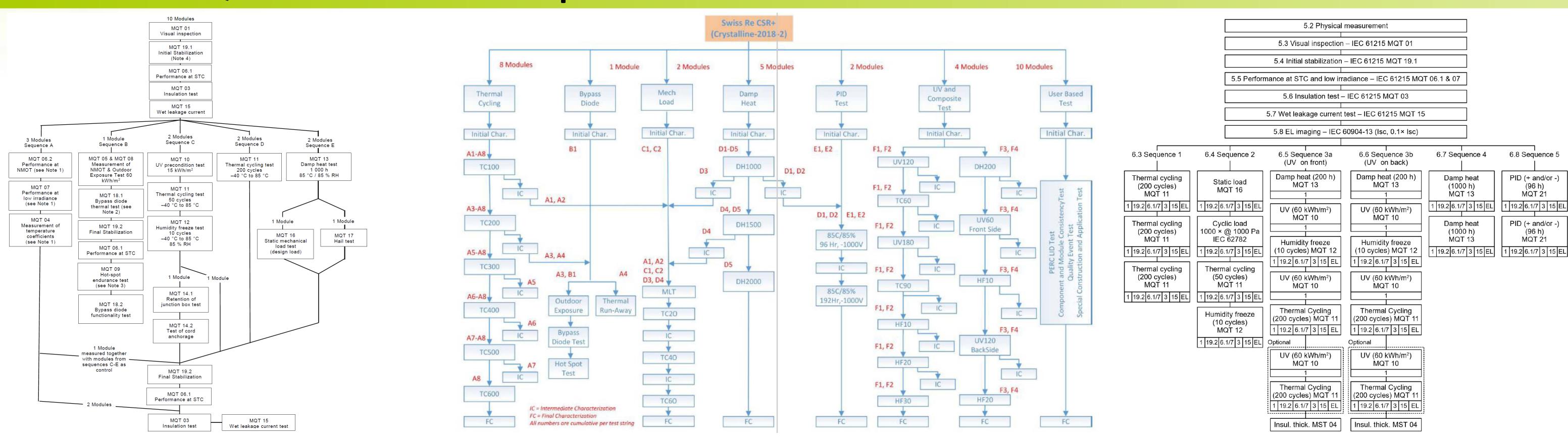
# Acceptable volume of investment for "Combined Stress Testing"

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#### Summary

The combined stress tests, in which some kinds of stressors simultaneously applied to the testing PV modules, have several advantages to contribute the risk avoidance on long-term operation of PV modules in fields (find the failure modes which are a-priori unknown in new module designs, reduction of potential risk, acceleration of the time to market of a product, and so on). Through the analyses for the cost-of-ownerships in the conventional qualification test and the proposed extended stress tests for PV modules, we predict that of a combined stress test, to clarify the acceptable level of investment for this novel test system. In this study, we demonstrate that, if we could develop the test equipment with a comparable cost to those required in these extended stress tests, the combined stress test would be accepted by all stake-holders in PV industry sector. Furthermore, it is suggested that the market penetration of this combined stress test would be facilitated by the equipment-improvement for the multi-module testing.

### **Conventional Qualification Test & Proposed Extended Stress Tests**



CSR+: 2018 [2]

### **Approach & Results**

IEC 61215-1-1: 2016 [1]

The cost-of-ownerships of the existing test system (IEC 61215-1-1) and 2 proposed protocol (CSR+ and IEC TS 63209 draft) were calculated, in reference to the total cost-of-ownership guide on PV cell manufacturing [4]–[6] (**Tables I, II, III**).

**Table I**: Spread sheet to be input the price and the depreciation period of equipment required in IEC 61215-1-1

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Table III: Annual cumulative tests in 3 test-protocols*								
Test Protocol	61215-1-1	CSR+	63209 draft					
Unit Tact (h)	1,300	3,700	3,700					
Ann. Turnover	6.45	2.33	2.33					
Parallel Tests	4	1	1					
Ann. Cumulative Tests (Tests/Year)	25.8	2.33	2.33					
Unit Modules/Test	10	32	50**					
Ann. Throughput (Modules/Year)	258	74.6	116.5					

**IEC TS 63209 draft [3]** 

\* The optional tests (e.g., the user-based tests defined in CSR+) are not included.

# Acceptable volume of investment (AVI) for the increasing in confidence on reliability = ca. 10-times of the unit cost in the conventional qualification test

Table IV: Assumed add-on process costs by cost element

		<b>1</b>									
		61215-2	1-1	-1 CSR+				63209 d	)9 draft		
1	Depreciation	319 k\$/y	26.9	%	0.83 -fold	23.5	%	0.80 -fold	22.5	%	
2	Floor space	444 k\$/y			1.00 -fold			1.00 -fold			
3	Materials/Consumables	41  k	52.4	%	1.00 -fold	54.9	%	1.00 -fold	55.4	%	
4	Utilities	54 k\$/y			1.00 -fold			1.00 -fold			
5	Waste Disposal	81 k\$/y			1.00 -fold			1.00 -fold			
6	Labor	245  k	20.7	%	1.00 -fold	21.7	%	1.00 -fold	21.7	%	
7	Cost of Yield Loss	0 k\$/y			0			0			
8	Cost of Ownership	1,183  k			1,130  k			1,120  k/y			
9	Ann. Cumulative Tests	25.8 tests/y			2.33 tests/y			2.33 test/y			
10	Unit Cost (Cost / Test)	46 k\$/test			485 k\$/test			480 k\$/test			

#### References

- [1] Terrestrial photovoltaic (PV) modules Design qualification and type approval Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules. IEC 61215-1-1: 2016, 2016.
- [2] J. Li and E. Hsi, Solar Panel Code of Practice International guideline on the risk management and sustainability of solar panel warranty insurance. Swiss Reinsurance, 2018.
- [3] Extended-stress testing of photovoltaic modules for risk analysis. IEC TS 63209 draft.
- 4] D. W. Jimenez, "Cost of ownership and overall equipment efficiency: a photovoltaics perspective," Photovoltaics International, pp. 16–22, 2009.
- [5] Guide to Calculate Cost of Ownership (COO) Metrics for Semiconductor Manufacturing Equipment. SEMI E35-0618, 2017.
- 6] SEMI and VDMA, "Calculate cost of ownership," 2014. [Online]. Available: http://www.itrpv.net/.cm4all/iproc.php/SEMI\_CoO\_Template\_20140218.xlsx?cdp=a.

<sup>\*\*</sup> Since the major objective of IEC TS 63209 draft is the risk-data collection on the testing PV modules, we assumed that the confidence in the test results would be emphasized by a large sample size (e.g., 10 modules/sequence).