

21080 Test Report:

IEC TS 63209-1 Sequence 1 Thermal Fatigue Testing on M390-D1FB Modules Produced by Mitrex

Report Number: 21080A-PR-E-001
Report Date: 2022-08-08
Test Period: 2022-02-07 to 2022-07-27
Project ID: 21080 (CFV), 000477 (Customer PO)
Customer: Hadi Khatibzadehazad / Mitrex
41 Racine Rd
Etobicoke, Ontario M9W 2Z4
Canada

Report Prepared by:	Report Reviewed by:	Report Approved by:

Project Summary

CFV Labs conducted extended reliability testing on two **M390-D1FB** modules produced by **Mitrex** per IEC TS 63209-1 Sequence 1 Thermal Fatigue.

The modules were subjected to performance measurements and safety tests prior to stress testing. The modules were then subjected to three rounds of TC200 for a total thermal cycling dose of 600 cycles. Each test block was followed by post-stress performance and safety measurements.

The average change in STC Pmp [W] from initial to the final post-stress testing was measured to be -5.93 %. The modules passed all safety tests and all initial, interim, and final visual inspections.

This report is sub-report 21080A-PR-E-001 of project 21080. All test legs for this IEC TS 63209-1 project are summarized in report 21080-PR-E-001.

Project Test Flow

The figure below shows the overall test flow for this project.

Incoming Inspection	Seq_1 Thermal Cycling	Seq_1 Thermal Cycling_Continued
All samples	21080-008, 21080-003	21080-008, 21080-003
@Initial	@Seq1_Initial	@Seq1_TC200-2
Incoming Inspection	MQT 06.1 Performance at STC	MQT 11 Thermal Cycling (200 Cycles)
MQT 01 Visual Inspection	MQT 07 Performance at Low Irradiance	MQT 01 Visual Inspection
EL Imaging 1.0x Isc	@Seq1_Stabilization-1	MQT 06.1 Performance at STC
EL Imaging 0.1x Isc	MQT 19 Stabilization - Outdoor Exposure (40 kWh/m ² , MPPT)	MQT 07 Performance at Low Irradiance
	MQT 06.1 Performance at STC	EL Imaging 1.0x Isc
	@Seq1_Stabilization-2	MQT 03 Insulation
	MQT 19 Stabilization - Outdoor Exposure (40 kWh/m ² , MPPT)	MQT 15 Wet Leakage Current
	MQT 06.1 Performance at STC	@Seq1_TC200-3
	@Seq1_Stabilization-3	MQT 11 Thermal Cycling (200 Cycles)
	MQT 19 Stabilization - Outdoor Exposure (40 kWh/m ² , MPPT)	MQT 01 Visual Inspection
	@Seq1_Stabilized	MQT 06.1 Performance at STC
	MQT 06.1 Performance at STC	MQT 07 Performance at Low Irradiance
	MQT 07 Performance at Low Irradiance	Bifacial Indoor I-V
	Bifacial Indoor I-V	EL Imaging 1.0x Isc
	EL Imaging 1.0x Isc	EL Imaging 0.1x Isc
	EL Imaging 0.1x Isc	MQT 03 Insulation
	MQT 03 Insulation	MQT 15 Wet Leakage Current
	MQT 15 Wet Leakage Current	
	@Seq1_TC200-1	
	MQT 11 Thermal Cycling (200 Cycles)	
	MQT 01 Visual Inspection	
	MQT 06.1 Performance at STC	
	MQT 07 Performance at Low Irradiance	
	EL Imaging 1.0x Isc	
	MQT 03 Insulation	
	MQT 15 Wet Leakage Current	

Test Flow Assignment

The modules utilized for this testing were supplied by the customer after they were inspected and sampled by PI Berlin for CFV Labs. The report, *CFV21080 Mitrex sample witness report 20220121_R2*, was provided separately to the customer.

These modules were free of obvious defects under visual inspection and electroluminescence imaging. The test flow assignment for each of the modules is provided in the table below. The modules were subjected to the test legs in the order listed.

Module ID	Serial Number	Test Leg(s)	Notes
21080-002	MIT21A04827	Incoming Inspection, Control	-
21080-003	MIT21A04820	Incoming Inspection, Seq_1 Thermal Cycling	-
21080-008	MIT22A00026	Incoming Inspection, Seq_1 Thermal Cycling	-

Sample Information

Sample Dimensions

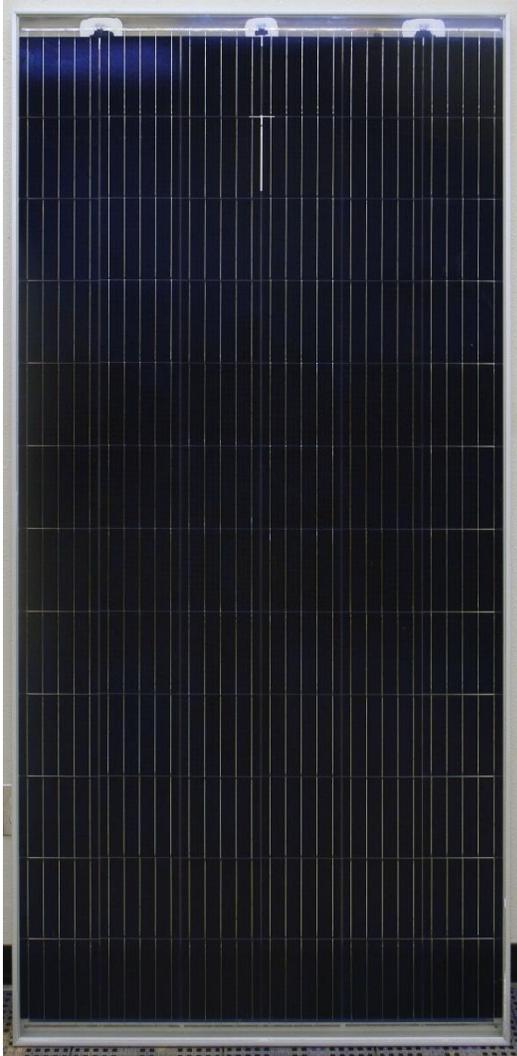
Module Type	Length [m]	Width [m]	Thickness [mm]
M390-D1FB	2.03	0.99	40

Sample Nameplate Values

Module Type	Isc [A]	Voc [V]	Imp [A]	Vmp [V]	Pmp [W]	Max Sys Volt [V]	Fuse Rating [A]
M390-D1FB	9.76	47.3	9.29	42.0	390	1000	20

Sample Type Images

Module Type: M390-D1FB





MITREX
41 Racine Rd, Toronto, ON M9W 2Z4, Canada
Tel: 1-416-497-7120
www.mitrex.com info@mitrex.com

MODULE TYPE	M390 - D1FB
Maximum Power (P _{max})	390
Max Power Tolerance	± 5 %
Maximum Power Voltage (V _{mp})	--- 42.0
Maximum Power Current (I _{mp})	9.29
Open Circuit Voltage (V _{oc})	--- 47.3
Short Circuit Current (I _{sc})	9.76
Max. system Voltage	--- 1000 V
Maximum overcurrent protection rating	20 A

All ratings at STC: E = 1000W/m² A = 1.5, T = 25°C
Accuracy of other electrical values ± 5 %

WARNING / ELECTRICAL HAZARD
This module produces electricity when exposed to sunlight. Do not disconnect the module under load.
Follow all applicable electrical safety precautions.



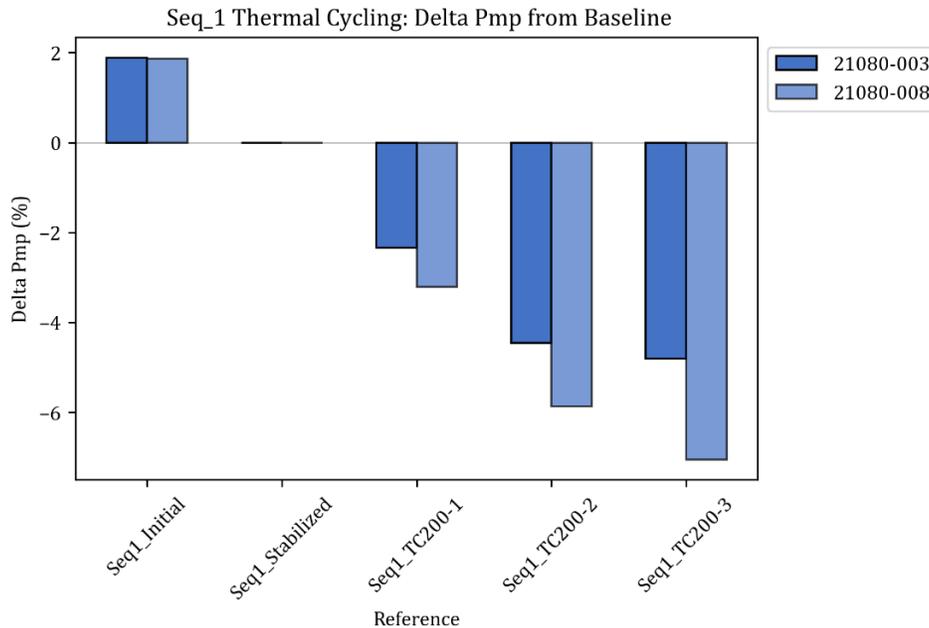
MADE IN CANADA

Results: Test Leg – Seq_1 Thermal Cycling

An incoming inspection report is provided separately to the customer. No issues were observed during the incoming inspection.

Summary of Results – Performance at STC and Safety Testing

The plots below show the Performance at STC measurement results as a change from Baseline (Stabilized).



The tables below show the Performance at STC, Visual Inspection, and safety testing results per module. When required, more detail is provided in the section referenced in the “Notes” field.

Test Conditions

Irradiance [W/m ²]	Temperature [°C]
1000.0	25.0

Estimated Measurement Uncertainty

Technology	Isc	Voc	Imp	Vmp	Pmp
Si, Bifacial (k=2)	± 1.6 %	± 0.75 %	± 2.1 %	± 1.3 %	± 2.2 %

Module: 21080-003

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.964	49.17	9.455	40.40	381.97	+1.89	pass	pass	pass
Stabilized	9.953	49.10	9.334	40.17	374.89	-	pass	pass	pass
TC200-1	9.937	48.95	9.315	39.30	366.12	-2.34	pass	pass	pass
TC200-2	9.882	48.91	9.177	39.03	358.20	-4.45	pass	pass	pass
TC200-3	9.909	49.03	9.182	38.87	356.91	-4.80	pass	pass	pass

Notes:

Module: 21080-008

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.983	49.18	9.508	40.68	386.76	1.86	pass	pass	pass
Stabilized	9.984	49.08	9.447	40.19	379.71	-	pass	pass	pass
TC200-1	9.936	48.93	9.365	39.25	367.52	-3.21	pass	pass	pass
TC200-2	9.851	48.97	9.186	38.91	357.41	-5.87	pass	pass	pass
TC200-3	9.923	49.02	9.198	38.37	352.93	-7.05	pass	pass	pass

Notes:

Performance at STC – Change from Stabilized

Module ID	Reference	Δ Isc [%]	Δ Voc [%]	Δ Imp [%]	Δ Vmp [%]	Δ Pmp [%]
21080-003	Initial	+0.12	+0.14	+1.30	+0.58	+1.89
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	TC200-1	-0.16	-0.31	-0.20	-2.15	-2.34
	TC200-2	-0.71	-0.38	-1.68	-2.82	-4.45
	TC200-3	-0.44	-0.14	-1.63	-3.22	-4.80
21080-008	Initial	-0.01	+0.20	+0.64	+1.21	+1.86
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	TC200-1	-0.48	-0.32	-0.87	-2.36	-3.21
	TC200-2	-1.33	-0.23	-2.76	-3.20	-5.87
	TC200-3	-0.61	-0.14	-2.64	-4.54	-7.05

Control Module Measurements

Module ID	Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)
21080-002	Initial	9.981	49.19	9.476	40.33	382.22
	Stabilized	9.975	49.14	9.450	40.19	379.84
	TC200-1	9.964	49.12	9.455	40.27	380.69
	TC200-2	9.943	49.07	9.428	40.23	379.31
	TC200-3	9.964	49.12	9.470	40.24	381.04

Bifacial Performance

Test Conditions

Irradiance [W/m ²]	Temperature [°C]
1000.0	25.0

Estimated Measurement Uncertainty

Technology	Isc	Voc	Imp	Vmp	Pmp
Si, Bifacial (k=2)	± 1.6 %	± 0.75 %	± 2.1 %	± 1.3 %	± 2.2 %

Measurements - Backside

Module ID	Reference	Isc [A]	Voc [V]	Imp [A]	Vmp [V]	Pmp [W]
21080-003	Stabilized	6.942	48.41	6.056	42.02	254.48
	TC200-3	6.737	48.32	6.026	40.94	246.70
21080-008	Stabilized	7.015	48.48	6.236	42.06	262.27
	TC200-3	6.806	48.29	6.069	40.44	245.41

Bifaciality Calculations

Module ID	Reference	φ _{Isc} [%]	φ _{Voc} [%]	φ _{Imp} [%]	φ _{Vmp} [%]	φ _{Pmp} [%]
21080-003	Stabilized	69.75	98.59	64.89	104.61	67.88
	TC200-3	67.99	98.54	65.63	105.32	69.12
21080-008	Stabilized	70.27	98.77	66.01	104.63	69.07
	TC200-3	68.59	98.51	65.98	105.39	69.53

Performance at Low Irradiance

Test Conditions

Irradiance [W/m ²]	Temperature [°C]
200.0	25.0

Estimated Measurement Uncertainty

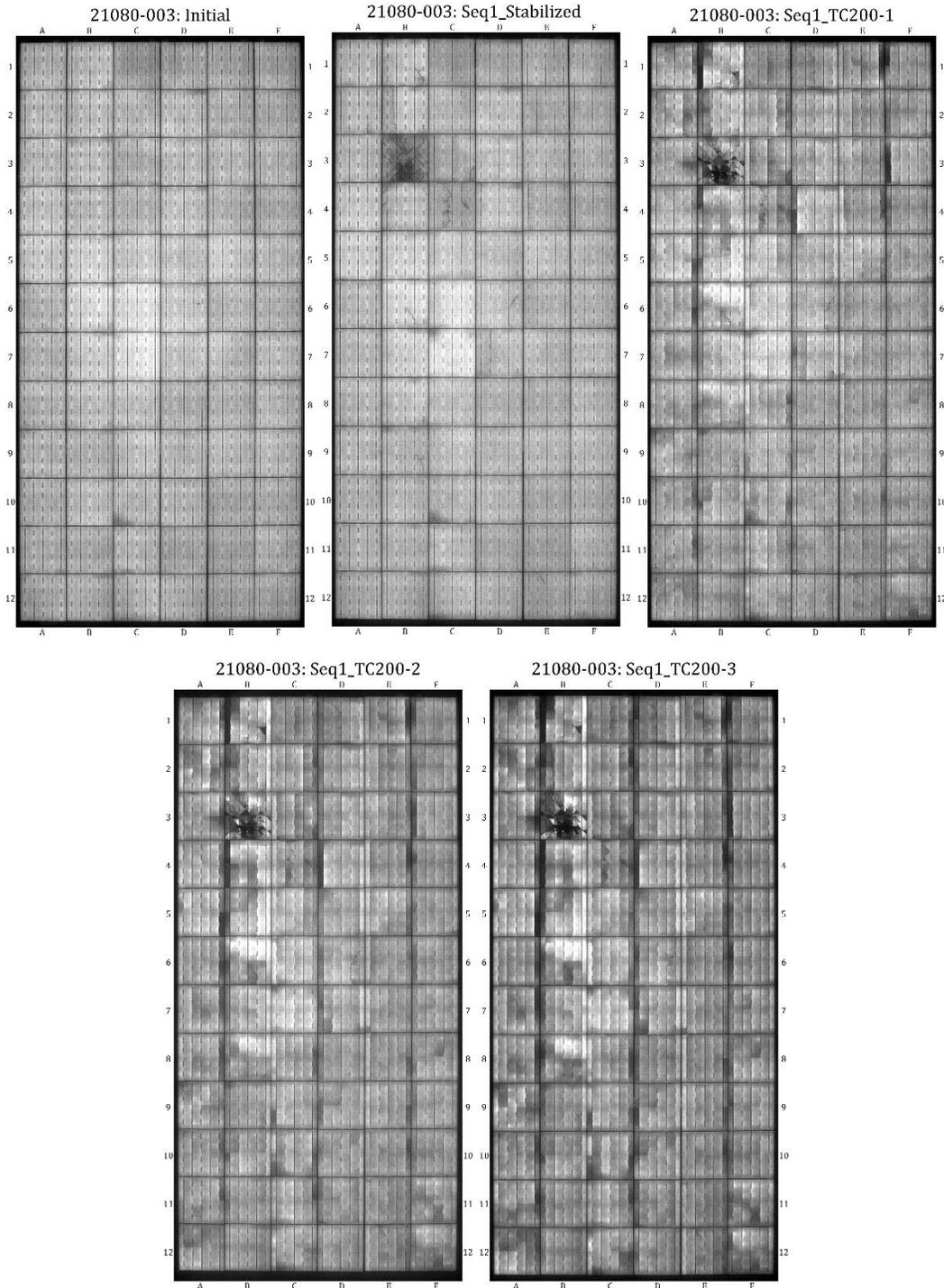
Technology	Isc	Voc	Imp	Vmp	Pmp
Si, Bifacial (k=2)	± 1.6 %	± 0.75 %	± 2.1 %	± 1.3 %	± 2.2 %

Measurements

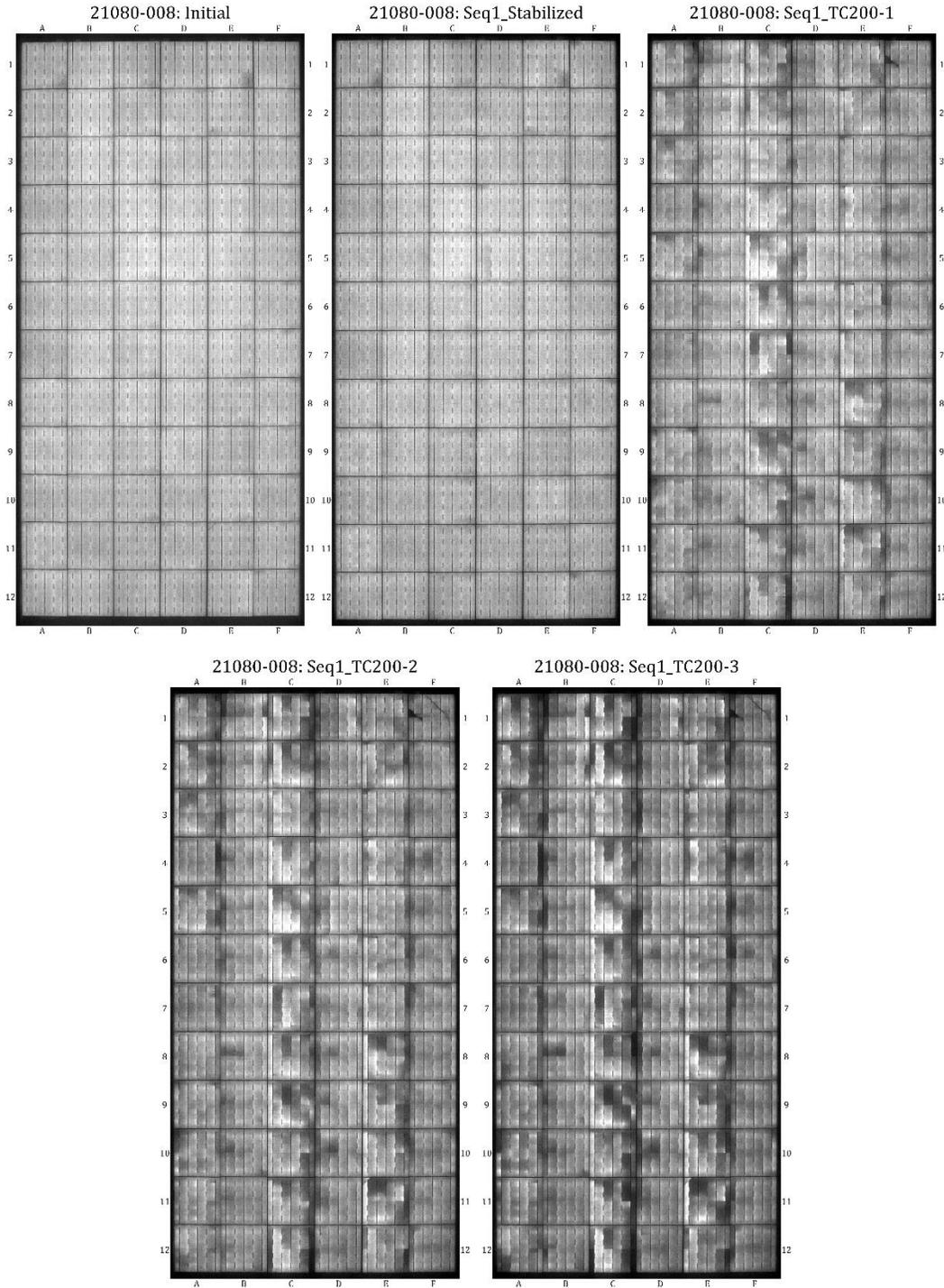
Module ID	Reference	Isc [A]	Voc [V]	Imp [A]	Vmp [V]	Pmp [W]
21080-003	Initial	1.990	46.14	1.885	39.52	74.51
	Stabilized	1.999	45.86	1.825	38.69	70.61
	TC200-1	1.994	45.82	1.857	38.76	71.96
	TC200-2	1.981	45.78	1.843	38.70	71.31
	TC200-3	1.996	45.76	1.861	38.60	71.86
21080-008	Initial	2.002	46.05	1.892	39.66	75.04
	Stabilized	2.003	45.98	1.886	39.26	74.05
	TC200-1	2.000	45.77	1.873	38.86	72.80
	TC200-2	1.988	45.66	1.856	38.68	71.80
	TC200-3	1.999	45.70	1.873	38.52	72.14

Electroluminescence Imaging

Module 21080-003 (Images taken at $0.1 \times I_{sc}$ are provided separately in digital format)



Module 21080-008 (Images taken at 0.1 x Isc are provided separately in digital format)



Stabilization

Pass/Fail also determined by follow-up MQT 01 Visual Inspection and MQT 15 Wet Leakage Current.

Module	Reference	Total Dose [kWh/m ²]	Pmp - Delta from Initial [%]
21080-003	Stabilized	141.27	-1.85
21080-008	Stabilized	99.99	-1.82
21080-002	Z_Stabilized	141.27	-0.62

Thermal Cycling

Pass/Fail also determined by follow-up MQT 01 Visual Inspection and MQT 15 Wet Leakage Current.

Module	Reference	Cycle Count	Total Cycle Count	Temp - High [°C]	Temp - Low [°C]	Pass/Fail
21080-003	TC200-1	200	200	85	-40	Pass
21080-003	TC200-2	200	400	85	-40	Pass
21080-003	TC200-3	200	600	85	-40	Pass
21080-008	TC200-1	200	200	85	-40	Pass
21080-008	TC200-2	200	400	85	-40	Pass
21080-008	TC200-3	200	600	85	-40	Pass

Procedures

The procedures for the testing contained in this report are summarized in the following table.

Test Name	Standard / Procedure	CFV Accreditation
Incoming Inspection	CFV	NA
Visual Inspection	IEC 61215-2:2016 MQT 01	ISO 17025
Electroluminescence Imaging	IEC TS 60904-13:2018	ISO 17025
Preconditioning	IEC 61215-2:2016 MQT 19	ISO 17025
Performance at STC	IEC 61215-2:2016 MQT 06.1	ISO 17025
Performance at Low Irradiance	IEC 61215-2:2016 MQT 07	ISO 17025
Wet Leakage Current	IEC 61215-2:2016 MQT 15	ISO 17025
Insulation	IEC 61215-2:2016 MQT 03	ISO 17025
Thermal Cycling	IEC 61215-2:2016 MQT 11	ISO 17025

Equipment Calibration Information

Equipment and Calibration information is available upon request.

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