

21080 Test Report:

IEC TS 63209-1 Sequence 2 Mechanical Stress Testing on M390-D1FB Modules Produced by Mitrex

Report Number: 21080B-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 2 Mechanical Stress.

The modules were subjected to performance measurements and safety tests prior to stress testing. One module was subjected to the whole sequence of Static Mechanical Loading (SMLT), Dynamic Mechanical Loading (DMLT), 50 thermal cycles (TC50), and 10 humidity/freezing cycles (HF10). A second module, used as a reference for mechanical stress, was subjected to DMLT, TC50, and HF10 only. Each test block on both modules was followed by post-stress performance and safety measurements.

The change in STC Pmp [W] from initial to the final post-stress testing for the standard and reference modules respectively was measured to be -11.89 % and -5.56 %. The modules passed all safety tests and all initial, interim, and final visual inspections.

This report is sub-report 21080B-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_2a SMLT	Seq_2b SMLT-Reference
All samples	21080-005	21080-009
@Initial	@Seq2a_Initial	@Seq2b_Initial
Incoming Inspection	MQT 06.1 Performance at STC	MQT 06.1 Performance at STC
MQT 01 Visual Inspection	MQT 07 Performance at Low Irradiance	MQT 07 Performance at Low Irradiance
EL Imaging 1.0x Isc	@Seq2a_Stabilization	@Seq2b_Stabilization
EL Imaging 0.1x Isc	MQT 19 Stabilization - Outdoor Exposure (120 kWh/m ² , MPPT)	MQT 19 Stabilization - Outdoor Exposure (120 kWh/m ² , MPPT)
	@Seq2a_Stabilized	@Seq2b_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
	@Seq2a_SMLT	@Seq2b_DMLT
	MQT 16 Static Mechanical Load (+/-2400 Pa)	Cyclic Mechanical Loading (+/-1000 Pa, 6 cycles/min)
	MQT 01 Visual Inspection	MQT 01 Visual Inspection
	MQT 06.1 Performance at STC	MQT 06.1 Performance at STC
	MQT 07 Performance at Low Irradiance	MQT 07 Performance at Low Irradiance
	EL Imaging 1.0x Isc	EL Imaging 1.0x Isc
	MQT 03 Insulation	MQT 03 Insulation
	MQT 15 Wet Leakage Current	MQT 15 Wet Leakage Current
	@Seq2a_DMLT	@Seq2b_TC50-1
	Cyclic Mechanical Loading (+/-1000 Pa, 6 cycles/min)	MQT 11 Thermal Cycling (50 Cycles)
	MQT 01 Visual Inspection	MQT 01 Visual Inspection
	MQT 06.1 Performance at STC	MQT 06.1 Performance at STC
	MQT 07 Performance at Low Irradiance	MQT 07 Performance at Low Irradiance
	EL Imaging 1.0x Isc	EL Imaging 1.0x Isc
	MQT 03 Insulation	MQT 03 Insulation
	MQT 15 Wet Leakage Current	MQT 15 Wet Leakage Current
	@Seq2a_TC50-1	@Seq2b_HF10-1
	MQT 11 Thermal Cycling (50 Cycles)	MQT 12 Humidity Freeze
	MQT 01 Visual Inspection	MQT 01 Visual Inspection (Within 2-4 hours following HF)
	MQT 06.1 Performance at STC	MQT 15 Wet Leakage Current (Within 2-4 hours following HF)
	MQT 07 Performance at Low Irradiance	MQT 06.1 Performance at STC
	EL Imaging 1.0x Isc	MQT 07 Performance at Low Irradiance
	MQT 03 Insulation	Bifacial Indoor I-V
	MQT 15 Wet Leakage Current	EL Imaging 1.0x Isc
	@Seq2a_HF10-1	EL Imaging 0.1x Isc
	MQT 12 Humidity Freeze	MQT 03 Insulation
	MQT 01 Visual Inspection (Within 2-4 hours following HF)	
	MQT 15 Wet Leakage Current (Within 2-4 hours following HF)	
	MQT 06.1 Performance at STC	
	MQT 07 Performance at Low Irradiance	
	Bifacial Indoor I-V	
	EL Imaging 1.0x Isc	
	EL Imaging 0.1x Isc	
	MQT 03 Insulation	

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	-
21080-005	MIT22A00020	Incoming Inspection, Seq_2a SMLT	-
21080-009	MIT21A04856	Incoming Inspection, Seq_2b SMLT-Reference	-

Sample Information

Sample Dimensions

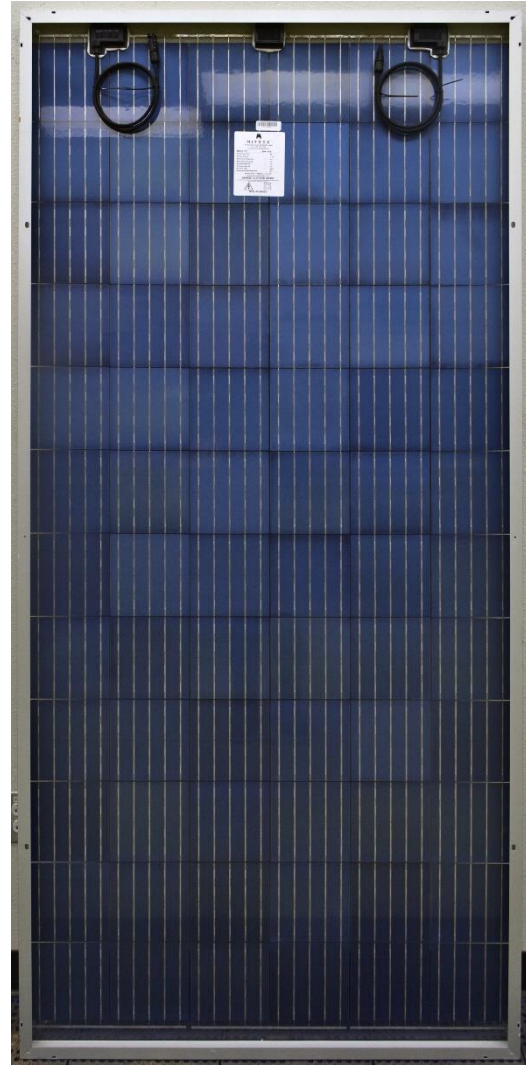
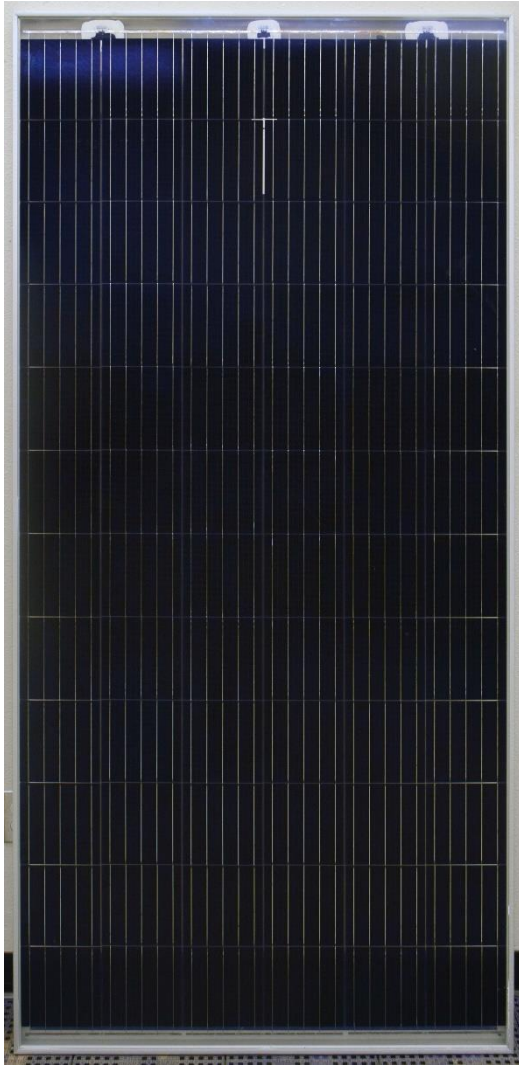
Module Type	Length [m]	Width [m]	Thickness [mm]
M390-D1FB	2.03	0.99	40


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 (Pmax)	390
Max Power Tolerance	± 5 %
Maximum Power Voltage (Vmp)	42.0
Maximum Power Current (Imp)	9.29
Open Circuit Voltage (Voc)	47.3
Short Circuit Current (Isc)	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.



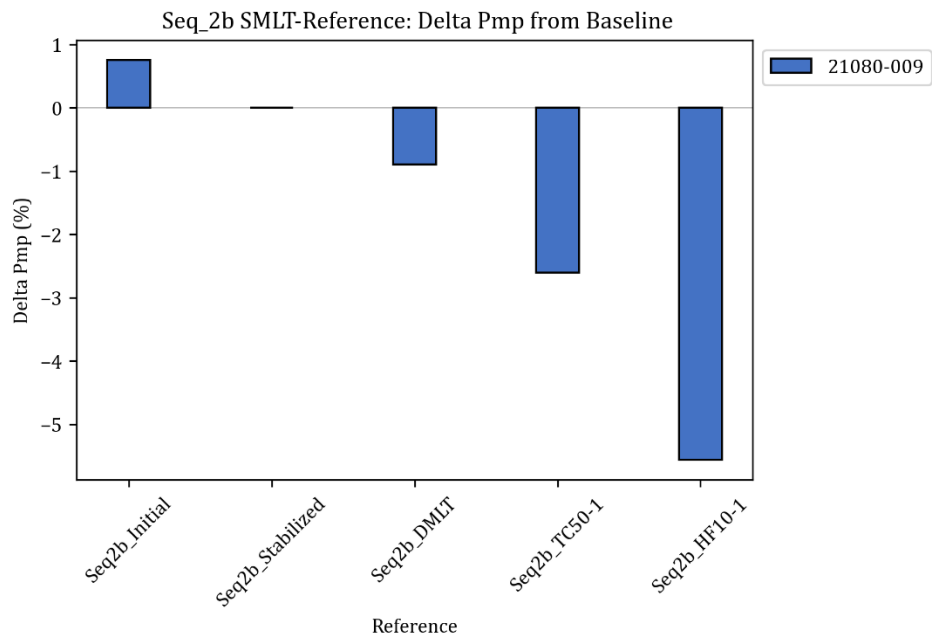
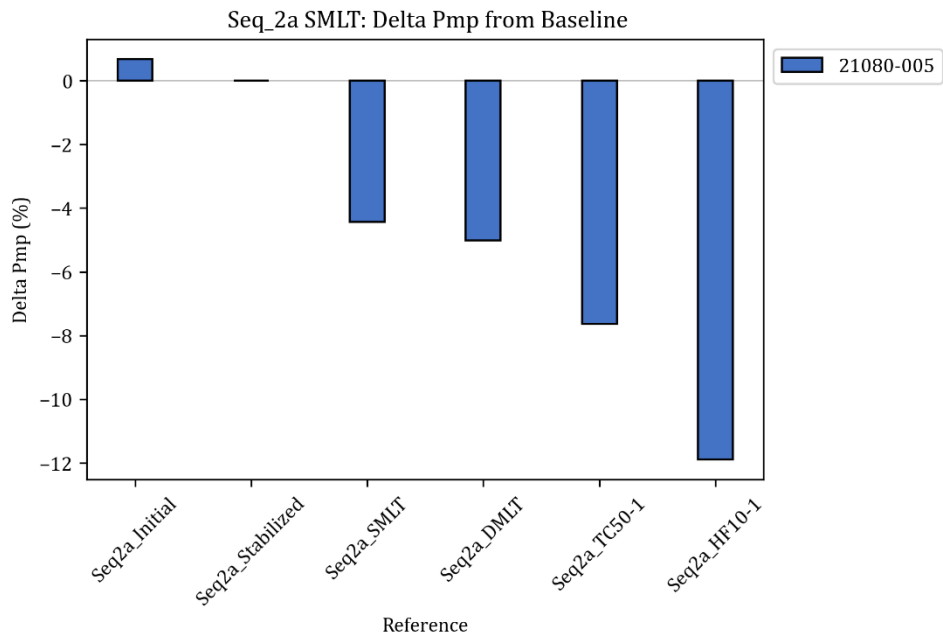
MADE IN CANADA

Results: Test Leg – Seq_2a SMLT and Seq2b SMLT-Reference

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/m2]	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: 21080-005

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.971	49.15	9.478	40.29	381.90	+0.67	pass	pass	pass
Stabilized	9.959	49.14	9.455	40.12	379.37	-	pass	pass	pass
SMLT	9.937	48.90	9.107	39.81	362.55	-4.43	pass	pass	pass
DMLT	9.941	48.91	9.051	39.81	360.37	-5.01	pass	pass	pass
TC50	9.965	48.82	8.942	39.18	350.37	-7.64	pass	pass	pass
HF10	9.814	48.81	8.631	38.73	334.26	-11.89	pass	pass	pass

Notes:

Module: 21080-009

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	10.002	49.15	9.468	40.29	381.46	+0.75	pass	pass	pass
Stabilized	9.975	49.12	9.439	40.11	378.61	-	pass	pass	pass
DMLT	9.956	49.04	9.377	40.02	375.23	-0.89	pass	pass	pass
TC50	9.983	48.94	9.321	39.56	368.77	-2.60	pass	pass	pass
HF10	9.842	48.97	9.076	39.40	357.57	-5.56	pass	pass	pass

Notes:

Performance at STC – Change from Stabilized

Module ID	Reference	Δ Isc [%]	Δ Voc [%]	Δ Imp [%]	Δ Vmp [%]	Δ Pmp [%]
21080-005	Initial	+0.12	+0.02	+0.24	+0.42	+0.67
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	SMLT	-0.22	-0.48	-3.68	-0.79	-4.43
	DMLT	-0.18	-0.46	-4.27	-0.78	-5.01
	TC50	0.06	-0.65	-5.42	-2.35	-7.64
	HF10	-1.46	-0.68	-8.71	-3.48	-11.89
21080-009	Initial	+0.27	+0.05	+0.31	+0.45	+0.75
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	DMLT	-0.19	-0.17	-0.66	-0.23	-0.89
	TC50	0.08	-0.37	-1.26	-1.36	-2.60
	HF10	-1.34	-0.32	-3.85	-1.78	-5.56

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
	SMLT	9.943	49.07	9.428	40.23	379.31
	DMLT	9.946	49.10	9.436	40.20	379.32
	TC50	9.971	49.17	9.468	40.25	381.12
	HF10	9.964	49.12	9.470	40.24	381.04

Bifacial Performance*Test Conditions*

Irradiance [W/m2]	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]
21080-005	Stabilized	7.011	48.45	6.261	41.81	261.80
	HF10	6.739	48.26	5.945	39.52	234.93
21080-009	Stabilized	7.013	48.58	6.330	41.90	265.18
	HF10	6.744	48.25	5.921	41.15	243.67

Bifaciality Calculations

Module ID	Reference	ϕ_{Isc} [%]	ϕ_{Voc} [%]	ϕ_{Imp} [%]	ϕ_{Vmp} [%]	ϕ_{Pmp} [%]
21080-005	Stabilized	70.40	98.59	66.22	104.20	69.01
	HF10	68.67	98.88	68.87	102.05	70.28
21080-009	Stabilized	70.30	98.91	67.06	104.45	70.04
	HF10	68.53	98.53	65.24	104.46	68.15

Performance at Low Irradiance

Test Conditions

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

Estimated Measurement Uncertainty

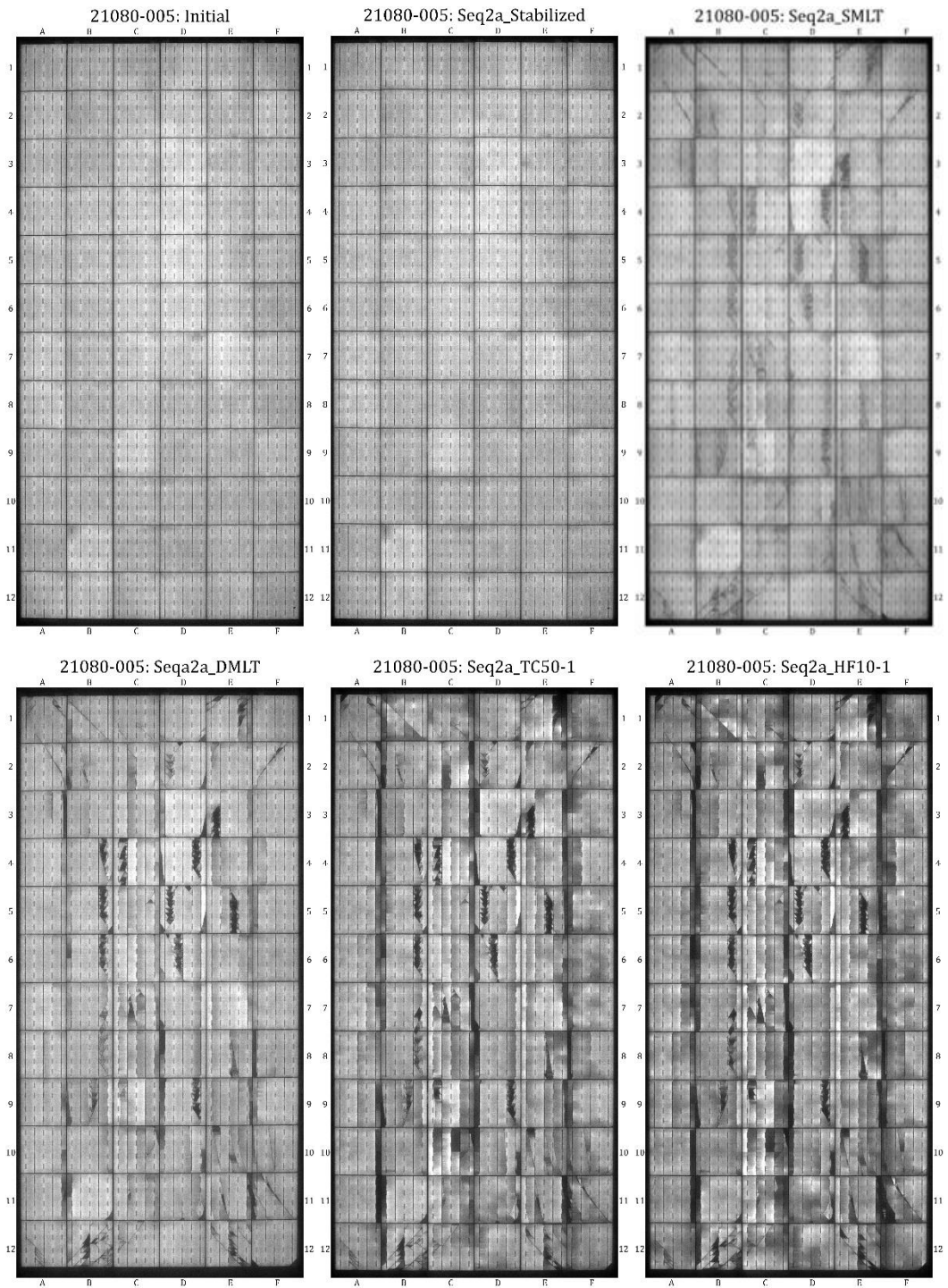
Technology	Isc	Voc	Imp	Vmp	Pmp
Si, Bifacial (k=2)	± 1.6 %	± 0.75 %	± 2.1 %	± 1.3 %	± 2.2 %

Measurements

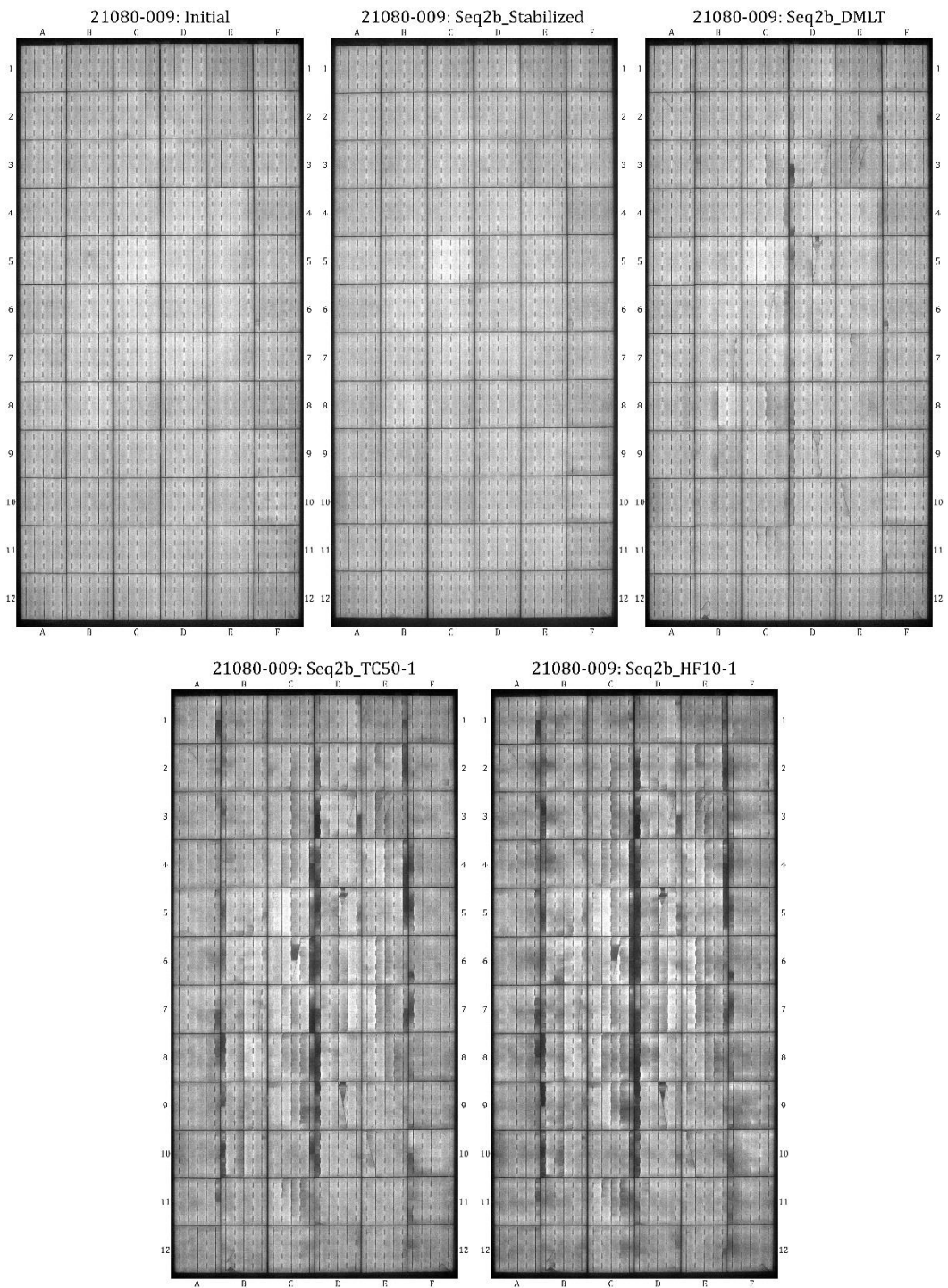
Module ID	Reference	Isc [A]	Voc [V]	Imp [A]	Vmp [V]	Pmp [W]
21080-005	Initial	1.993	46.02	1.890	39.35	74.36
	Stabilized	2.000	45.97	1.884	39.29	74.03
	SMLT	1.992	45.34	1.718	37.05	63.64
	DMLT	1.997	45.58	1.800	38.20	68.75
	TC50	1.997	45.51	1.810	38.00	68.77
	HF10	1.979	45.49	1.780	37.86	67.39
21080-009	Initial	1.996	46.08	1.889	39.40	74.42
	Stabilized	2.007	45.96	1.882	39.21	73.79
	DMLT	1.992	45.91	1.851	39.01	72.20
	TC50	2.008	45.68	1.876	38.63	72.46
	HF10	1.978	45.64	1.845	38.55	71.14

Electroluminescence Imaging

Module 21080-005 (Images taken at 0.1 x Isc are provided separately in digital format)



Module 21080-009 (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 [%]
21080-005	Stabilized	145.78	-0.66
21080-009	Stabilized	145.78	-0.75
21080-002	Z_Stabilized	141.27	-0.62

Static Mechanical Loading

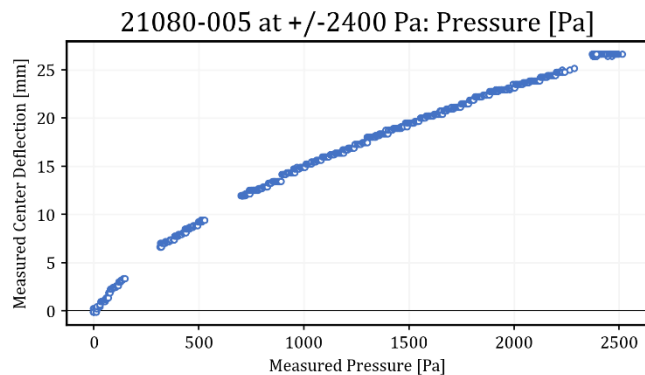
Pass/Fail also determined by follow-up MQT 01 Visual Inspection and MQT 15 Wet Leakage Current. Module was installed on the two support rails of the mechanical load tester running parallel to the module short-side. It was secured using industry standard 100 mm top clamps at the long-side quarter points.

Module	Test Reference	Cycle Count	Pressure - Down [Pa]	Pressure - Up [Pa]	Pass/Fail
21080-005	Seq2a_SMLT	3	2400	-2400	Pass

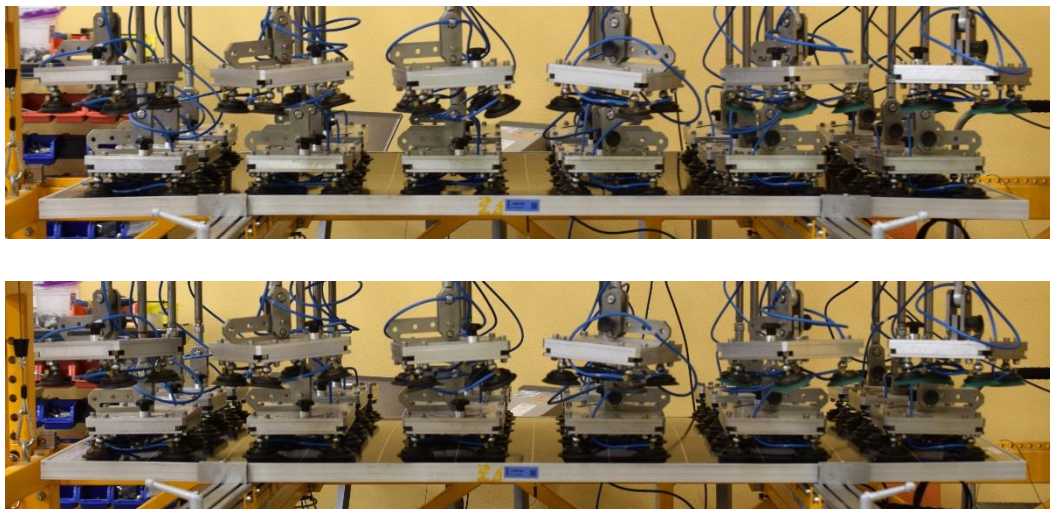
Module 21080-005

Pressure vs Deflection Plot and Data

Pressure [Pa]	Deflection [mm]	Deflection [in]
0	0.00	0.00
200	2.90	0.11
400	7.54	0.30
600	9.38	0.37
800	12.59	0.50
1000	14.96	0.59
1200	16.74	0.66
1400	18.61	0.73
1600	20.19	0.80
1800	21.83	0.86
2000	23.33	0.92
2200	24.51	0.97
2400	26.61	1.05



Module Deflection Images at Maximum Downward (Top) and Upward Loads (Bottom)



Cyclic (Dynamic) Mechanical Loading

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

Module	Test Reference	Cycle Count	Pressure - High [Pa]	Pressure - Low [Pa]	Pass/Fail
21080-005	Seq2a_DMLT	1000	1000	-1000	Pass
21080-009	Seq2b_DMLT	1000	1000	-1000	Pass

Thermal Cycling

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

Module	Test Reference	Cycle Count	Total Cycle Count	Temp - High [°C]	Temp - Low [°C]	Pass/Fail
21080-005	Seq2a_TC50	50	50	85	-40	Pass
21080-009	Seq2b_TC50	50	50	85	-40	Pass

Humidity Freeze

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

Module	Test Reference	Cycle Count	Total Cycle Count	Temp - High [°C]	Temp - Low [°C]	Humidity [% RH]	Pass/Fail
21080-005	Seq2a_HF10	10	10	85	-40	85	Pass
21080-009	Seq2b_HF10	10	10	85	-40	85	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
Static Mechanical Loading	IEC 61215-2:2016 MQT 16	ISO 17025
Cyclic (Dynamic) Mechanical Loading	IEC TS 62782:2016	ISO 17025
Thermal Cycling	IEC 61215-2:2016 MQT 11	ISO 17025
Humidity Freeze	IEC 61215-2:2016 MQT 12	ISO 17025

Equipment Calibration Information

Equipment and Calibration information is available upon request.

Disclaimer and Conditions of Report Reproduction

1. *CFV Solar Test Laboratory, Inc. (dba "CFV Labs" or "CFV") is an independent third-party laboratory and as such does not represent the interest of any other party in any capacity. As part of our ISO 17025 accreditation, impartiality is fundamental to our business.*
2. *This test report represents the commercially reasonable good-faith efforts of CFV Labs to fulfilling the goals of the client's mutually agreed upon test project with CFV Labs. There are no warranties expressed or implied for the test results.*
3. *When possible, CFV Labs follows published standards (by IEC, ANSI, etc.) to which it has ISO 17025 accreditation to perform tests. However, some test projects require testing for which there is no published standard. For these projects, or portions of projects, CFV agrees with the client ahead of time on a test procedure that may be able to accomplish the objectives of the project.*
4. *Whether standards-based testing or custom testing is done, there is no guarantee or warranty expressed or implied that the results will completely answer questions or concerns the client may have about the items tested.*
5. *This report is the property of the client and may be shared in full with third parties at the client's discretion. CFV Labs will not share or discuss the results of this report with any third party without the client's permission. However, this report may not be shared or reproduced except in full without CFV Labs' permission. The use of CFV Labs' name or logo attached to any portion of the results, except for in the form of the full report, is not permitted without CFV Labs' permission.*
6. *The test results in this report apply only to the specific items tested by CFV Labs and no claim is expressed or implied that they apply to other similar items whether CFV Labs was involved in the sampling of the items tested or not. The test results in this report do not imply either the suitability or unsuitability of any of the items tested for any particular application and no opinion is expressed by CFV Labs on that herein.*
7. *The test results in this report do not imply the responsibility or lack of responsibility of any party, financial or otherwise, as to the condition or performance of the items tested by CFV Labs, or any similar items not tested by CFV Labs, and no opinion is expressed on that herein.*

--END OF REPORT--