

21080 Test Report:

IEC TS 63209-1 Extended Stress Testing on M390-D1FB Modules Produced by Mitrex

Report Number: 21080-PR-E-001
Report Date: 2022-11-23
Test Period: 2022-02-07 to 2022-11-18
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 twelve **M390-D1FB** modules produced by **Mitrex** per IEC TS 63209-1:2021 Extended Stress Testing. This protocol consists of five test legs: Thermal Cycling, Mechanical Degradation, UV Backsheet Stress, Humidity, and Potential Induced Degradation.

All modules were subjected to MQT 19 Stabilization, performance measurements, and safety tests prior to stress testing. The modules were then subjected to the following stresses based on test leg:

Control Module Measurements: One control module, taken from the sample set that was provided for testing, was stabilized and measured each time test modules were. A repeatability of ± 0.45 %, which is the standard deviation ($k=2$) of Pmp of all control module measurements following stabilization, was adopted for this project.

Thermal Fatigue: two modules experienced three rounds of TC200 for a total thermal cycling dose of 600 cycles. The average performance change following testing was -5.93 %. The modules passed all initial, interim, and final visual inspections and safety tests.

Mechanical Stress: One module was subjected to SMLT followed by DMLT, TC50 and HF10. A second module, used as a mechanical degradation reference, skipped SMLT, but was subjected to all other tests. The performance change following testing was -11.89 % and -5.56 % for the SMLT and SMLT-Reference modules respectively. The modules passed all initial, interim, and final visual inspections and safety tests.

Sequential Testing Including UV Stress to Module Back-side: One module was subjected to DH200, followed by (UV60 > TC50 > HF10) repeated three times for a total dose of 180 kWh/m² of UV exposure, 150 thermal cycles and 30 humidity/freeze cycles. This is a backsheet specific test leg, so performance was not measured for degradation. The module tested *passed* all initial, interim, and final visual inspections and safety tests.

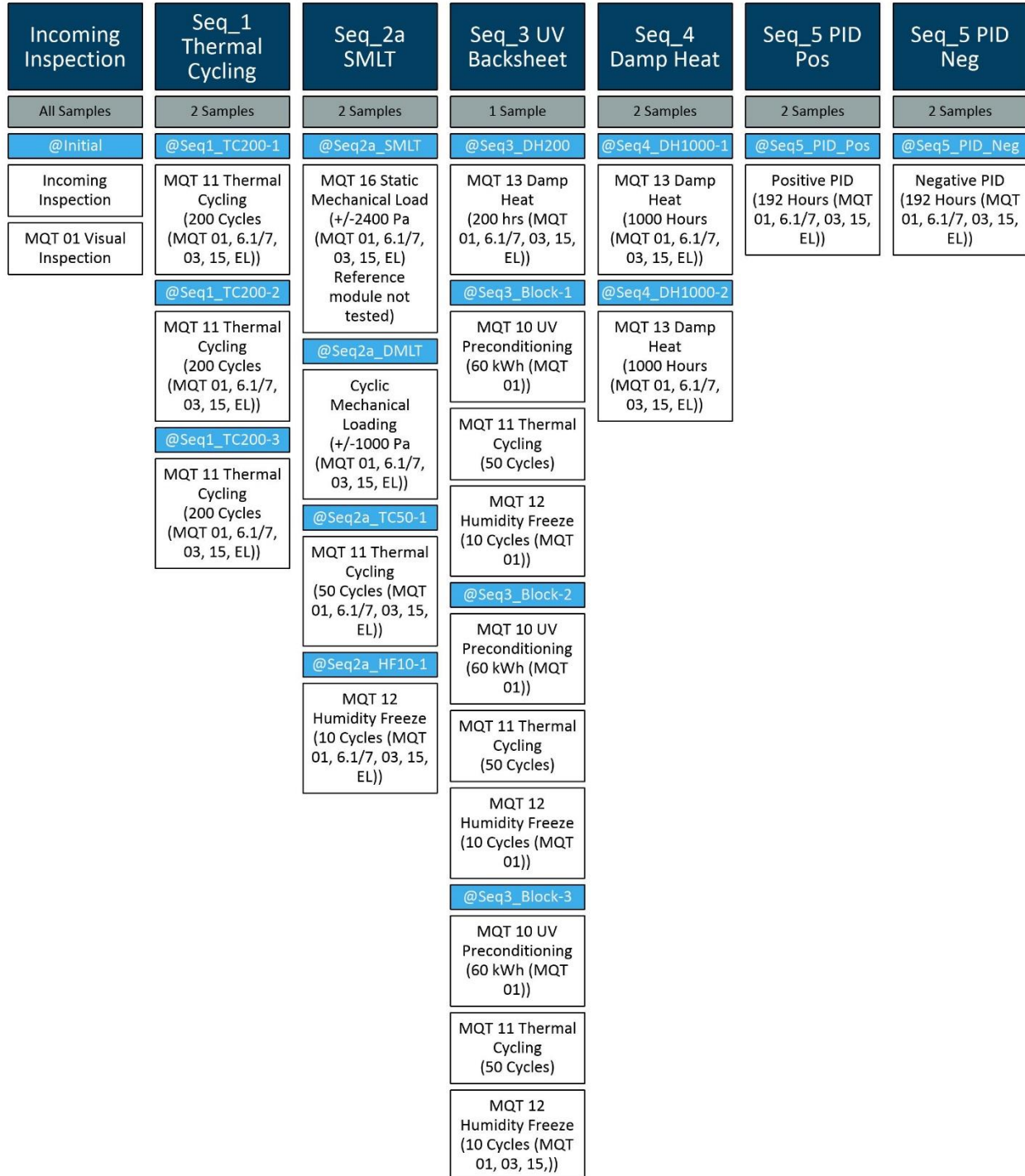
Damp Heat: Two modules experienced two rounds of DH1000 for a total damp heat dose of 2000 hours. The average performance change following testing was -4.70 %. The modules passed all initial, interim, and final visual inspections and safety tests.

Potential Induced Degradation (PID): Four modules experienced one round of 192 hours of PID testing, two in the positive bias configuration, two in the negative bias configuration. The average performance change following testing was -3.05 % and -47.91 % in the positive and negative bias configuration respectively. The modules passed all initial, interim, and final visual inspections and safety tests.

This report is the summary report, which covers the following sub-reports: 21080A-PR-E-001 Sequence 1 Thermal Cycling Test Report, 21080B-PR-E-001 Sequence 2 Mechanical Stress Test Report, 21080C-PR-E-001 Sequence 3 Mechanical Stress Test Report, 21080D-PR-E-001 Sequence 4 Damp Heat Test Report, and 21080E-PR-E-001 Sequence 5 Potential Induced Degradation Test Report.

Project Test Flow

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



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
21080-001	MIT21A04828	Incoming Inspection	-
21080-002	MIT21A04827	Incoming Inspection, Seq_Z_Control	-
21080-003	MIT21A04820	Incoming Inspection, Seq_1 Thermal Cycling	-
21080-004	MIT22A00019	Incoming Inspection, Seq3_UV_Backsheet	-
21080-005	MIT22A00020	Incoming Inspection, Seq_2a SMLT	-
21080-006	MIT22A00023	Incoming Inspection	-
21080-007	MIT22A00022	Incoming Inspection	-
21080-008	MIT22A00026	Incoming Inspection, Seq_1 Thermal Cycling	-
21080-009	MIT21A04856	Incoming Inspection, Seq_2b SMLT-Reference	-
21080-010	MIT21A04876	Incoming Inspection, Seq_4 Damp Heat	-
21080-011	MIT21A04883	Incoming Inspection	-
21080-012	MIT21A04880	Incoming Inspection	-
21080-013	MIT22A00010	Incoming Inspection, Seq_4 Damp Heat	-
21080-014	MIT22A00009	Incoming Inspection, Seq_5 PID_Pos	-
21080-015	MIT22A00008	Incoming Inspection	-
21080-016	MIT22A00003	Incoming Inspection	-
21080-017	MIT22A00002	Incoming Inspection	-
21080-018	MIT22A00005	Incoming Inspection	-
21080-019	MIT21A04888	Incoming Inspection	-
21080-020	MIT21A04872	Incoming Inspection, Seq_5 PID_Pos	-
21080-021	MIT21A04871	Incoming Inspection, Seq_5 PID_Neg	-
21080-022	MIT21A04869	Incoming Inspection	-
21080-023	MIT21A04849	Incoming Inspection	-
21080-024	MIT21A04840	Incoming Inspection	-
21080-025	MIT21A04822	Incoming Inspection, Seq_5 PID_Neg	-
21080-026	MIT21A04825	Incoming Inspection	-
21080-027	MIT21A04833	Incoming Inspection	-
21080-028	MIT21A04834	Incoming Inspection	
21080-029	MIT21A04829	Incoming Inspection	
21080-030	MIT21A04824	Incoming Inspection	

Sample Information

Sample Dimensions

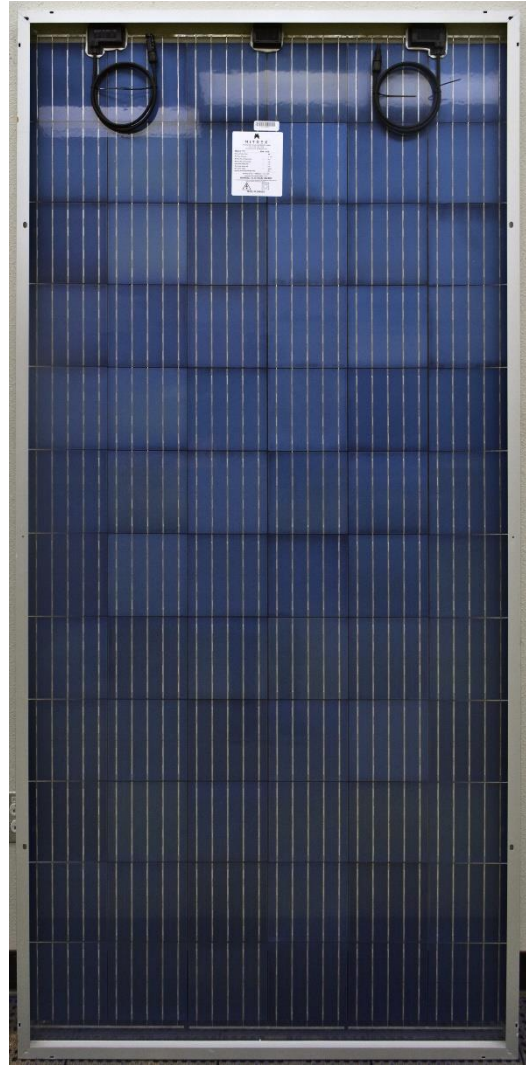
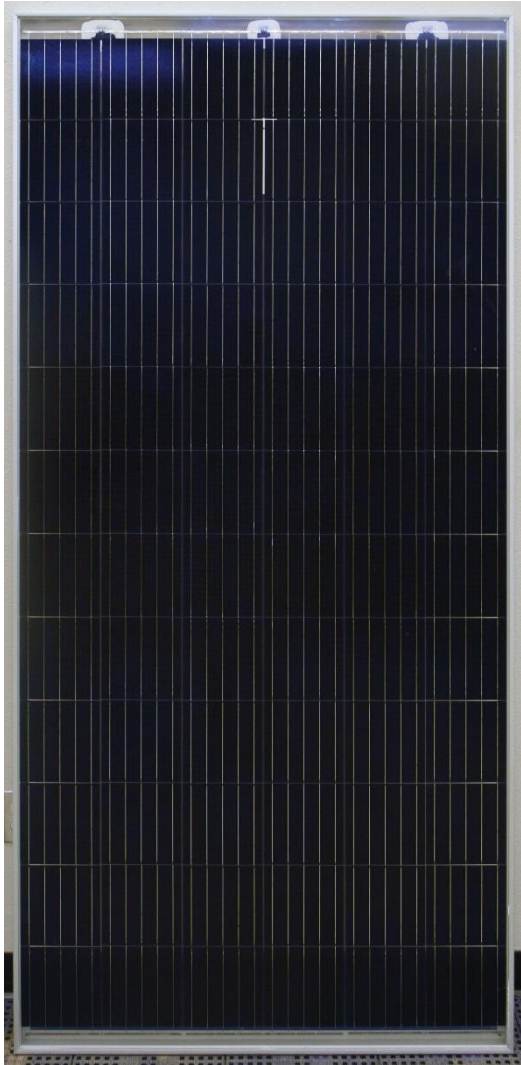
Module Type	Length [m]	Width [m]	Thickness [mm]
M390-D1FB	2.03	0.99	40


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

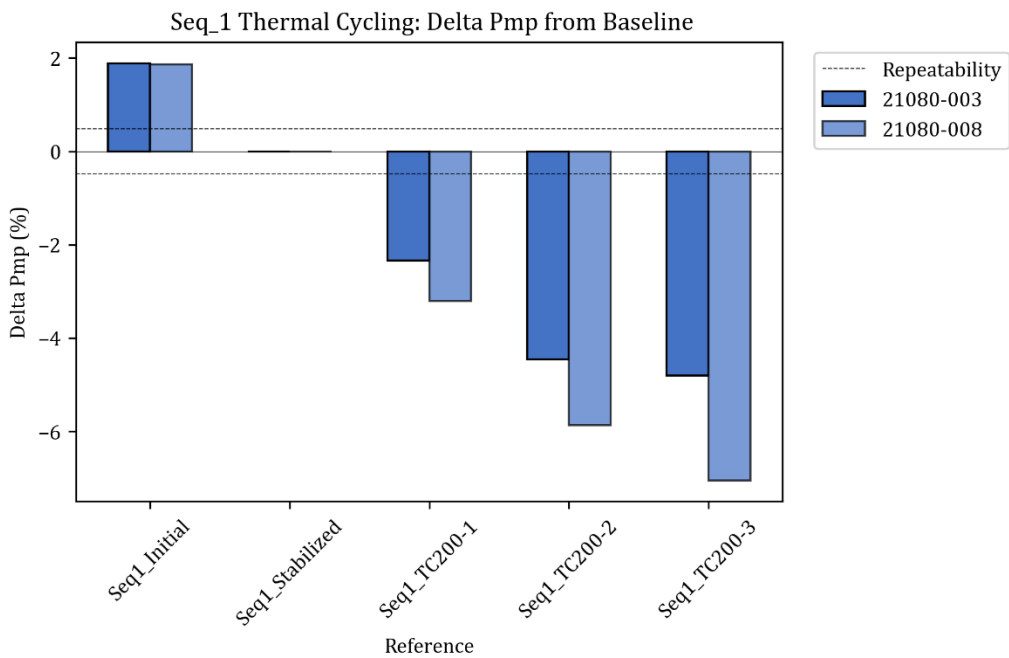
Results: Test Leg – Incoming Inspection

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

Results: Test Leg – Seq_1 Thermal Cycling

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).



Note: Repeatability was calculated as the standard deviation (k=2) of the control module results measured during this project following MQT 19 stabilization. The control modules were taken from the modules provided for this project.

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.

A module’s ΔPmp (%) was calculated as the change from the *stabilized* value.

Module: 21080-003

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	Δ Pmp (%)	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

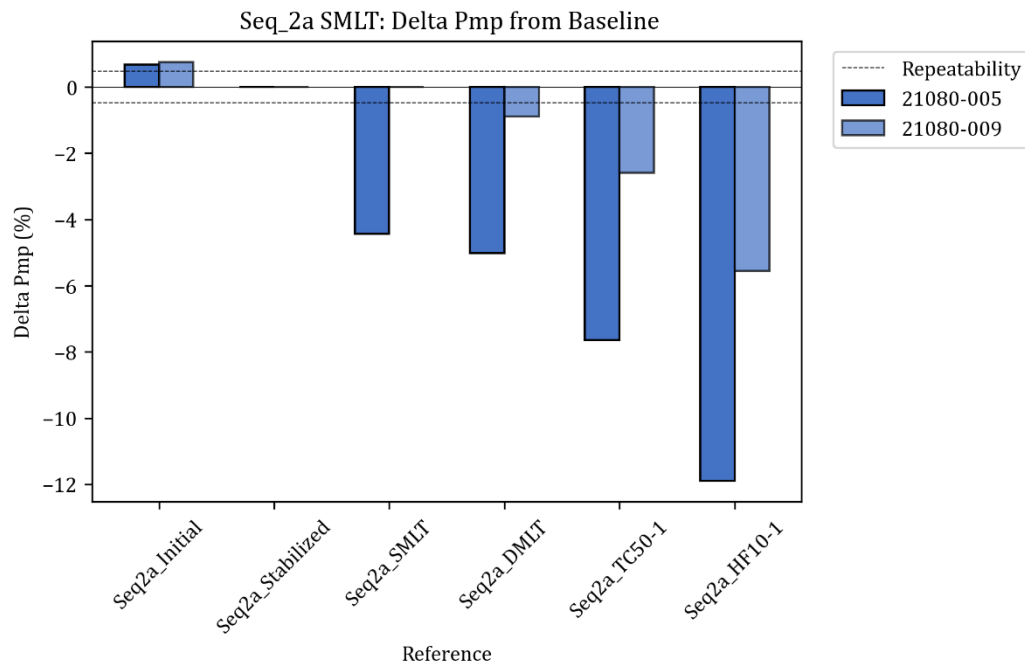
Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	Δ Pmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.983	49.18	9.508	40.68	386.76	1.86	pass	pass	pass
Stabilized	9.984	49.08	9.447	40.19	379.71	-	pass	pass	pass
TC200-1	9.936	48.93	9.365	39.25	367.52	-3.21	pass	pass	pass
TC200-2	9.851	48.97	9.186	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:

Results: Test Leg – Seq_2 Mechanical Stress - SMLT

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).



Note: Repeatability was calculated as the standard deviation ($k=2$) of the control module results measured during this project following MQT 19 stabilization. The control modules were taken from the modules provided for this project.

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.

A module’s ΔPmp (%) was calculated as the change from the *stabilized* value.

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 (Mechanical degradation reference module)

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
SMLT	-	-	-	-	-	-	-	-	-
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: As the mechanical degradation reference, this module was not subjected to SMLT in the test flow

Results: Test Leg – Seq_3_UV_Backsheet**Summary of Results – Performance at STC and Safety Testing**

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.

A module’s ΔP_{mp} (%) was calculated as the change from the *stabilized* value.

Module: 21080-004

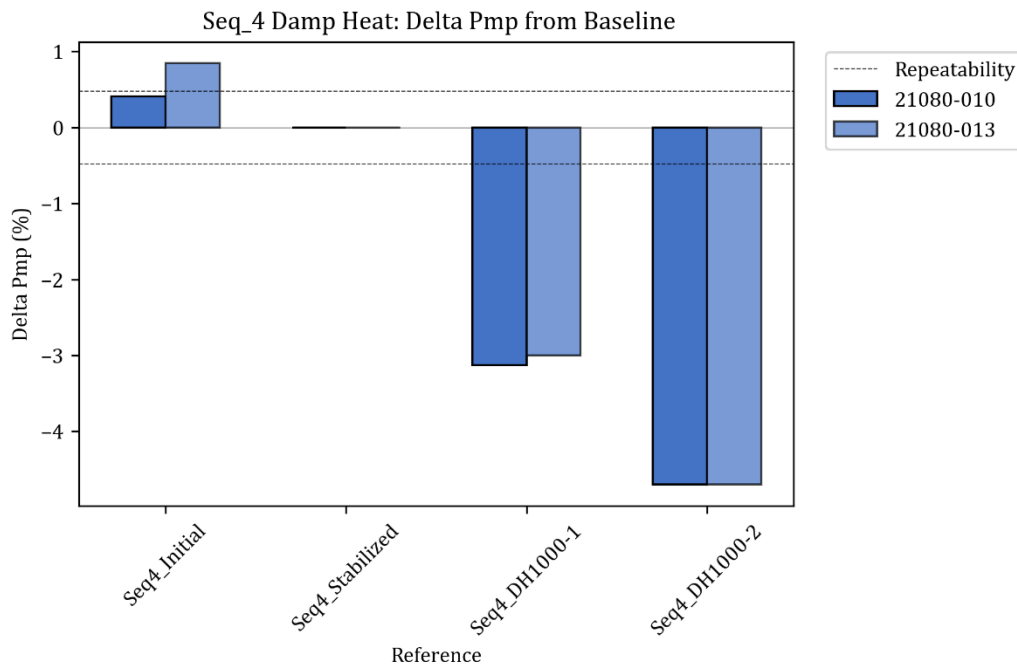
Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔP_{mp} (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.987	49.15	9.489	40.29	382.29	+0.84	pass	pass	pass
Stabilized	9.972	49.11	9.448	40.12	379.09	-	pass	pass	pass
DH200	-	-	-	-	-	-	pass	-	-
HF10-1	-	-	-	-	-	-	pass	-	-
HF10-2	-	-	-	-	-	-	pass	-	-
HF10-3	-	-	-	-	-	-	pass	pass	pass

Notes: This test leg is a backsheet test, so performance was not conducted for the majority of the project. Visual inspection of the module backsheet was conducted using 10x magnification.

Results: Test Leg – Seq_4 Damp Heat

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).



Note: Repeatability was calculated as the standard deviation ($k=2$) of the control module results measured during this project following MQT 19 stabilization. The control modules were taken from the modules provided for this project.

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.

A module’s ΔPmp (%) was calculated as the change from the *stabilized* value.

Module: 21080-010

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.968	49.17	9.458	40.37	381.83	+0.41	pass	pass	pass
Stabilized	9.977	49.08	9.437	40.30	380.28	-	pass	pass	pass
DH1000-1	9.756	48.90	9.227	39.92	368.38	-3.13	pass	pass	pass
DH1000-2	9.699	49.00	9.131	39.69	362.39	-4.70	pass	pass	pass

Notes:

Module: 21080-013

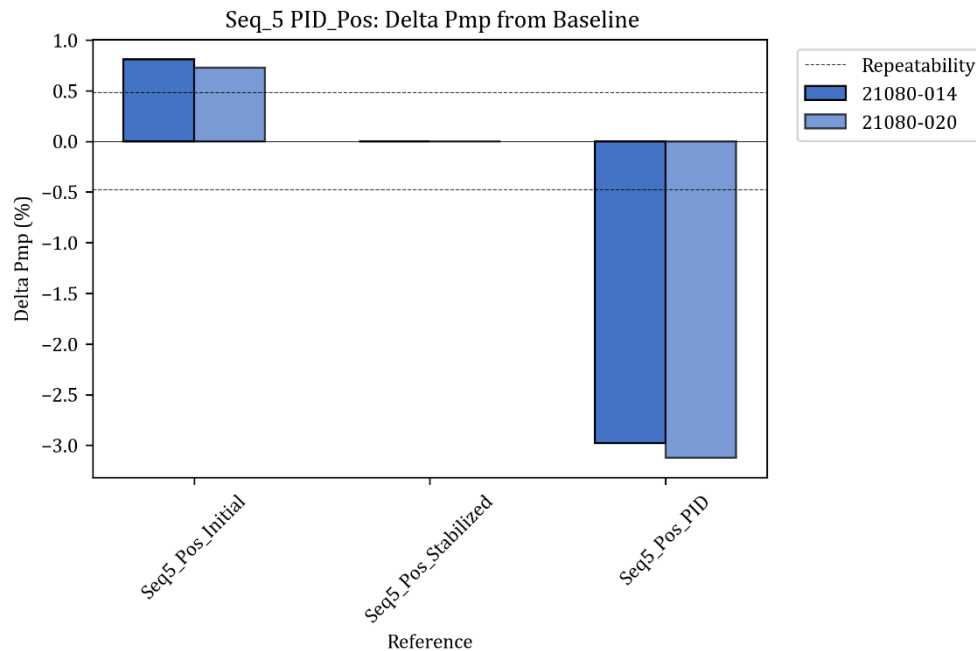
Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	Δ Pmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.991	49.22	9.472	40.45	383.12	+0.85	pass	pass	pass
Stabilized	9.976	49.12	9.423	40.32	379.91	-	pass	pass	pass
DH1000-1	9.780	48.87	9.241	39.88	368.52	-3.00	pass	pass	pass
DH1000-2	9.723	48.92	9.138	39.62	362.07	-4.70	pass	pass	pass

Notes:

Results: Test Leg – Seq_5 Potential-Induced Degradation (PID) Testing (Positive Bias Configuration)

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).



Note: Repeatability was calculated as the standard deviation ($k=2$) of the control module results measured during this project following MQT 19 stabilization. The control modules were taken from the modules provided for this project.

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.

A module’s ΔPmp (%) was calculated as the change from the *stabilized* value.

Module: 21080-014

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.984	49.10	9.473	40.29	381.68	+0.81	pass	pass	pass
Stabilized	9.958	49.12	9.422	40.18	378.60	-	pass	pass	pass
PID_Pos	9.821	48.78	9.230	39.80	367.30	-2.98	pass	pass	pass

Notes:

Module: 21080-020

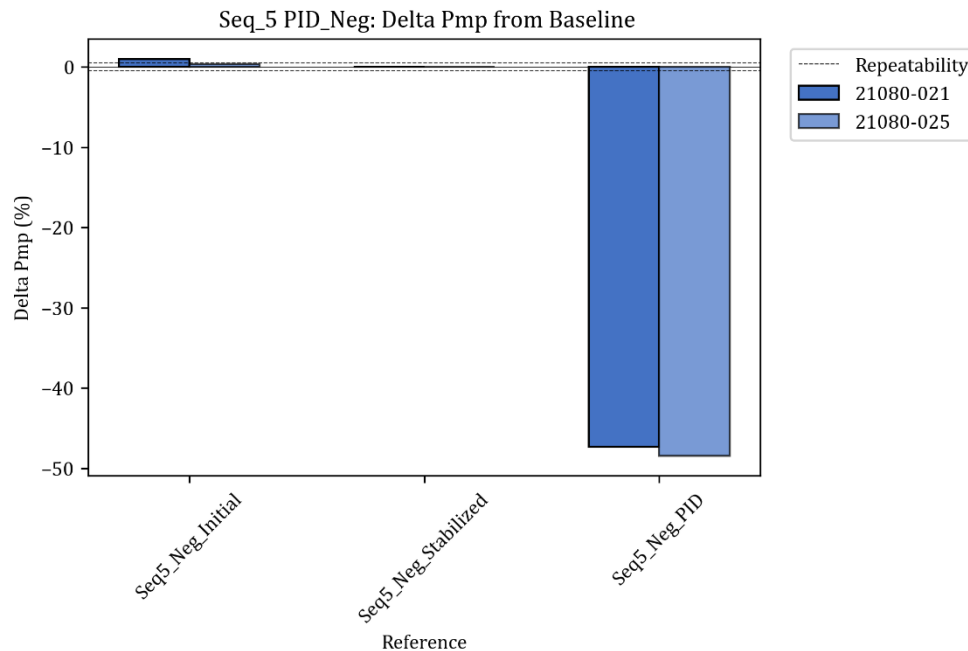
Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	Δ Pmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.978	49.10	9.465	40.34	381.84	+0.73	pass	pass	pass
Stabilized	9.952	49.12	9.428	40.20	379.05	-	pass	pass	pass
PID_Pos	9.798	48.85	9.217	39.84	367.21	-3.12	pass	pass	pass

Notes:

Results: Test Leg - Seq_5 Potential-Induced Degradation (PID) Testing (Negative Bias Configuration)

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).



Note: Repeatability was calculated as the standard deviation ($k=2$) of the control module results measured during this project following MQT 19 stabilization. The control modules were taken from the modules provided for this project.

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.

A module’s ΔPmp (%) was calculated as the change from the *stabilized* value.

Module: 21080-021

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.996	49.21	9.479	40.43	383.30	+1.00	pass	pass	pass
Stabilized	9.972	49.05	9.428	40.25	379.51	-	pass	pass	pass
PID_Neg	9.782	41.65	7.315	27.32	199.84	-47.34	pass	pass	pass

Notes:

Module: 21080-025

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	Δ Pmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	10.002	49.15	9.470	40.29	381.55	+0.38	pass	pass	pass
Stabilized	9.990	49.06	9.464	40.16	380.10	-	pass	pass	pass
PID_Neg	9.788	40.58	7.395	26.48	195.84	-48.48	pass	pass	pass

Notes:

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
Stabilization	IEC 61215-2:2016 MQT 19	ISO 17025
² Performance at STC	IEC 61215-2:2016 MQT 06.1	ISO 17025
³ Performance at Low Irradiance	IEC 61215-2:2016 MQT 07	ISO 17025
Bifacial IV	IEC TS 62094-1-2:2019	ISO 17025
Wet Leakage Current	IEC 61215-2:2016 MQT 15	ISO 17025
Insulation	IEC 61215-2:2016 MQT 03	ISO 17025
¹ Static Mechanical Loading	IEC 61215-2:2016 MQT 16	ISO 17025
Cyclic Mechanical Loading	IEC TS 62782-2:2016	ISO 17025
UV	IEC 61215-2:2016 MQT 10	ISO 17025
Thermal Cycling	IEC 61215-2:2016 MQT 11	ISO 17025
Humidity Freeze	IEC 61215-2:2016 MQT 12	ISO 17025
Damp Heat	IEC 61215-2:2016 MQT 13	ISO 17025
Potential Induced Degradation	IEC TS 62804:2015	ISO 17025

Amendments to tests:

¹ IEC 61215-2:2016 MQT 19, requires that modules are operated with MPPT and are measured at multiple intervals during the light exposure to determine stability. For this project, three of the modules tested were measured according to the full MQT 19 protocol (21080-002, 21080-003, and 21080-008). However, the standard allows for the use of an alternative procedure that is validated against the full protocol. In this case, the remaining modules were exposed to the same total dose, but they were only measured before and after the total dose and were operated in open circuit.

² Performance at STC - Test Conditions

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

Performance at STC - Estimated Measurement Uncertainty

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

³ Performance at Low Irradiance - Test Conditions

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

Performance at Low Irradiance - Estimated Measurement Uncertainty

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

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--