

21080 Test Report: IEC 61215-2:2016 MQT 17 Hail Testing Report on M390-D1FB Modules Produced by Mitrex

Report Number: 21080-PR-E-002
Report Date: 2022-11-21
Test Period: 2022-02-07 to 2022-11-03
Project ID: 21080 (CFV), 000477 (Customer PO)
Customer: Hadi Khatibzadehazad / Mitrex
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Report Prepared by:	Report Reviewed by:	Report Approved by:

Project Summary

CFV Labs conducted hail testing on three **M390-D1FB** modules produced by **Mitrex** per IEC 61215-2:2016 MQT 17.

The modules were subjected to stabilization prior to initial performance measurements and safety tests. Stress testing consisted of hail testing using either 45 mm ice balls (two modules tested) or 55 mm ice balls (one module tested). Following each stress test, performance measurements and safety tests were conducted.

Both modules (22081-027, -028) tested using 45 mm ice balls passed all initial and final safety testing. The average change in STC Pmp [W] from the stabilized value to the final post-stress testing was measured to be **-3.14% and -3.35%**.

The module (22081-026) tested using 55 mm ice balls failed due to front-side glass cracking resulting from the first impact. No further testing was conducted.

Project Test Flow

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

Incoming Inspection	Seq_Hail
All samples	21080-026, 21080-027, 21080-028
@Initial	@Seq_Hail_Initial
Incoming Inspection	MQT 01 Visual Inspection
MQT 01 Visual Inspection	MQT 06.1 Performance at STC
EL Imaging 1.0x Isc	MQT 07 Performance at Low Irradiance
EL Imaging 0.1x Isc	@Seq_Hail_Stabilization
	MQT 19 Stabilization - Outdoor Exposure (120 kWh/m ² , MPPT)
	@Seq_Hail_Stabilized
	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
	MQT 15 Wet Leakage Current
	@Seq_Hail
	MQT 17 Hail
	MQT 01 Visual Inspection
	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
	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	-
21080-026	MIT21A04825	Incoming Inspection, Seq_Hail	-
21080-027	MIT21A04833	Incoming Inspection, Seq_Hail	-
21080-028	MIT21A04834	Incoming Inspection, Seq_Hail	-

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





Results: Test Leg – Seq_Hail

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 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: 21080-026

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.972	49.23	9.456	40.43	382.29	+0.68	pass	pass	pass
Stabilized	9.946	49.09	9.433	40.25	379.71	-	pass	pass	pass
Hail	-	-	-	-	-	-	-	-	-

Notes: Hail test using 55 mm Ice balls. Module failed during hail testing, so no post-hail measurements were conducted

Module: 21080-027

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.978	49.12	9.479	40.27	381.74	+0.85	pass	pass	pass
Stabilized	9.907	49.09	9.394	40.30	378.53	+0.00	pass	pass	pass
Hail	9.872	48.91	9.171	39.98	366.65	-3.14	pass	pass	pass

Notes: Hail test using 45 mm Ice balls

Module: 21080-028

Reference	Isc (A)	Voc (V)	Imp (A)	Vmp (V)	Pmp (W)	ΔPmp (%)	Visual Inspection	Wet Leakage	Insulation
Initial	9.973	49.19	9.472	40.42	382.89	+0.73	pass	pass	pass
Stabilized	9.928	49.08	9.435	40.29	380.13	+0.00	pass	pass	pass
Hail	9.870	49.04	9.195	39.96	367.39	-3.35	pass	pass	pass

Notes: Hail test using 45 mm Ice balls

Performance at STC – Change from Stabilized

Module ID	Reference	ΔI_{sc} [%]	ΔV_{oc} [%]	ΔI_{mp} [%]	ΔV_{mp} [%]	ΔP_{mp} [%]
21080-026	Initial	+0.26	+0.29	+0.25	+0.43	+0.68
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	Hail	-	-	-	-	-
21080-027	Initial	+0.72	+0.08	+0.91	-0.06	+0.85
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	Hail	-0.35	-0.35	-2.37	-0.79	-3.14
21080-028	Initial	+0.45	+0.22	+0.40	+0.33	+0.73
	Stabilized	+0.00	+0.00	+0.00	+0.00	+0.00
	Hail	-0.58	-0.09	-2.54	-0.83	-3.35

Control Module Measurements

Module ID	Reference	I_{sc} (A)	V_{oc} (V)	I_{mp} (A)	V_{mp} (V)	P_{mp} (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
	Hail	9.943	49.07	9.428	40.23	379.31

Bifacial Performance

Test Conditions

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

Estimated Measurement Uncertainty

Technology	I_{sc}	V_{oc}	I_{mp}	V_{mp}	P_{mp}
Si, Bifacial (k=2)	± 1.6 %	± 0.75 %	± 2.1 %	± 1.3 %	± 2.2 %

Measurements - Backside

Module ID	Reference	I_{sc} [A]	V_{oc} [V]	I_{mp} [A]	V_{mp} [V]	P_{mp} [W]
21080-026	Stabilized	6.772	48.59	5.300	43.60	231.08
	Hail	-	-	-	-	-
21080-027	Stabilized	6.824	48.57	5.372	43.48	233.54
	Hail	6.739	48.28	5.354	42.86	229.49
21080-028	Stabilized	6.858	48.54	5.282	43.64	230.51
	Hail	6.801	48.29	5.264	43.01	226.39

Bifaciality Calculations

Module ID	Reference	$\phi_{I_{sc}}$ [%]	$\phi_{V_{oc}}$ [%]	$\phi_{I_{mp}}$ [%]	$\phi_{V_{mp}}$ [%]	$\phi_{P_{mp}}$ [%]
21080-026	Stabilized	68.09	98.98	56.18	108.32	60.86
	Hail	-	-	-	-	-
21080-027	Stabilized	68.88	98.94	57.18	107.89	61.70
	Hail	68.26	98.69	58.38	107.21	62.59
21080-028	Stabilized	69.08	98.90	55.99	108.31	60.64
	Hail	68.91	98.47	57.25	107.64	61.62

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]
21080-026	Initial	1.994	46.10	1.890	39.45	74.58
	Stabilized	1.991	46.06	1.886	39.39	74.29
	Hail	-	-	-	-	-
21080-027	Initial	1.991	46.09	1.888	39.44	74.47
	Stabilized	1.991	45.96	1.884	39.37	74.18
	Hail	1.981	45.57	1.806	37.89	68.42
21080-028	Initial	1.993	46.06	1.888	39.48	74.54
	Stabilized	1.991	45.98	1.886	39.45	74.41
	Hail	1.976	45.54	1.823	37.90	69.08

Stabilization

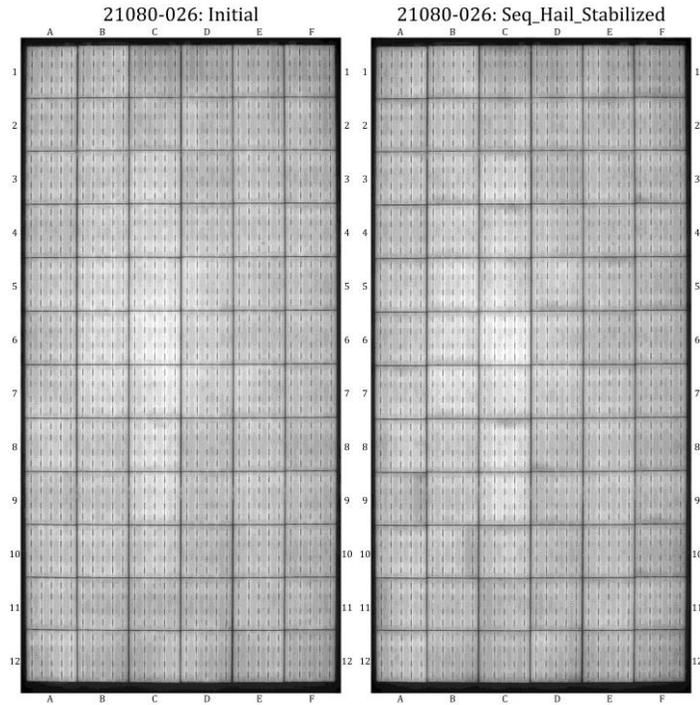
Test Results

Module	Reference	Total Irradiance Dose [kWh/m ²]	Pmp - Delta from Initial [%]
21080-026	Stabilized	145.78	-0.68
21080-027	Stabilized	145.78	-0.75
21080-028	Stabilized	145.78	-0.83
21080-002	Z_Stabilized	141.27	-0.62

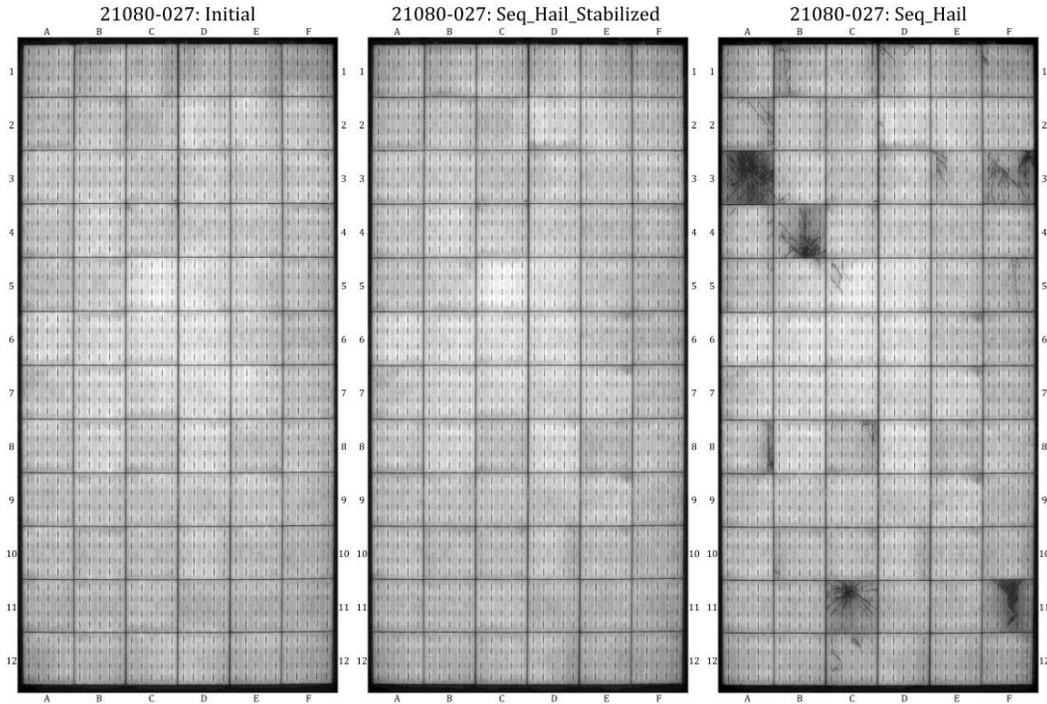
Electroluminescence Imaging

Module 21080-026 (Images taken at $0.1 \times I_{sc}$ are provided separately in digital format)

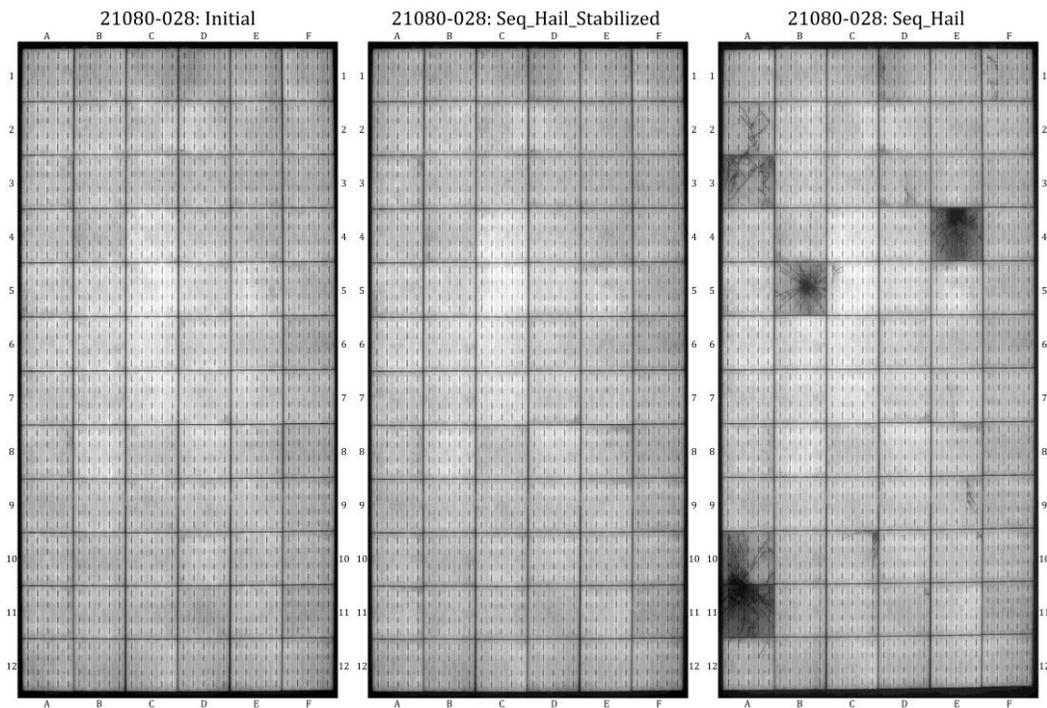
Due to failure during hail testing, no final EL was taken.



Module 21080-027 (Images taken at 0.1 x Isc are provided separately in digital format)



Module 21080-028 (Images taken at 0.1 x Isc are provided separately in digital format)



MQT 17 Hail Test

Pass/Fail also determined by follow-up MQT 01 Visual Inspection and MQT 15 Wet Leakage Current. Those results are presented in § *Summary of Results – Performance at STC and Safety Testing* above.

MQT 17 Hail Test Impact Locations

Shot No.	Location
1	Any corner of the module window, not more than one radius from the module edge.
2	Any edge of the module, not more than one radius of ice-ball from the module edge.
3, 4	Over edges of the circuit (e.g. individual cells).
5, 6	Over the circuit near interconnects (i.e. cell interconnects and bus ribbons).
7, 8	On the module window, not more than half diameter of ice ball from one of the points at which the module is mounted to the supporting structure.
9, 10	On the module window, at points farthest from the points selected above.
11	Any points which may prove especially vulnerable to hail impact like over the junction box.

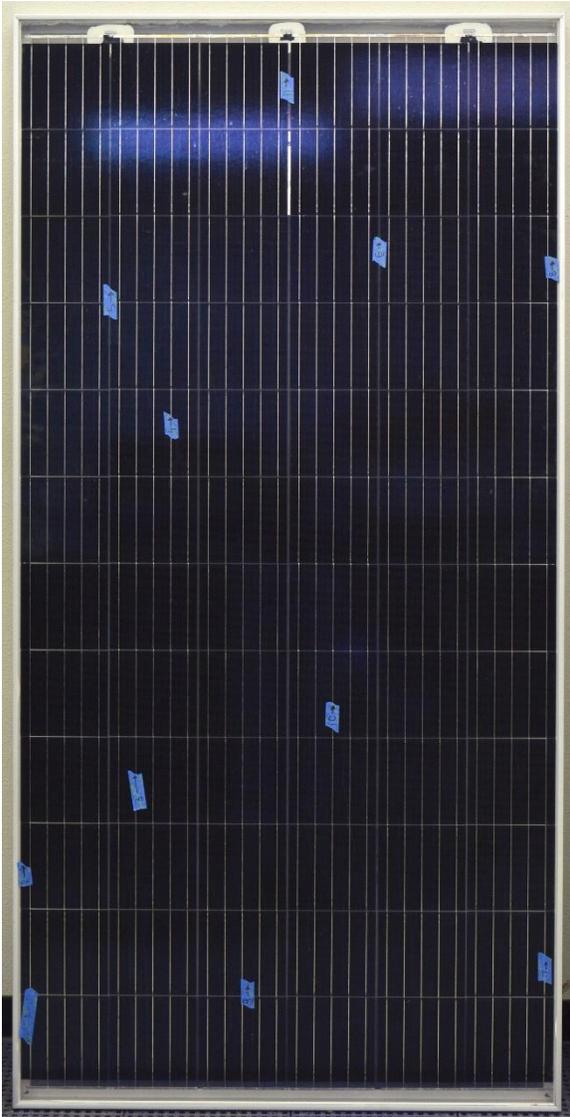
MQT 17 Hail Test Impact Results

	21080-026	21080-027	21080-028
Impact Location	Angle: 0° Size: 55 mm	Angle: 0° Size: 45 mm	Angle: 0° Size: 45 mm
1	Fail	Pass	Pass
2	-	Pass	Pass
3	-	Pass	Pass
4	-	Pass	Pass
5	-	Pass	Pass
6	-	Pass	Pass
7	-	Pass	Pass
8	-	Pass	Pass
9	-	Pass	Pass
10	-	Pass	Pass
11	-	Pass	Pass

21080-026 (Impact #1 Result – Glass cracking)



20180-027 (Impacts marked in blue)



21080-028 (Impacts marked in blue)



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
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
Hail Testing	IEC 61215-2:2016 MQT 17	ISO 17025

Equipment Calibration Information

Equipment and Calibration information is available upon request.

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