

24028 Test Report: Hail Testing of Mitrex M355-CL01F612 Modules

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Project ID: 24028 (CFV), P0002123 (Customer PO)
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Project Summary

CFV Labs conducted Hail testing on three **M355-CL01F612** modules with 6mm front-side glass and AHC backed honeycomb backside produced by **Mitrex** and provided by the manufacturer. An incoming inspection report, sample images and EL images were provided separately to the customer. Visual inspection, EL imaging and Performance at STC tests were conducted before and after Hail testing.

The main results after the Hail test are provided in the table below:

Module ID	Serial Number	Test	Result
24028-001	MIT24A00245	MQT 01 Visual Inspection	Pass
		MQT 06.1 Performance at STC	353.15 W
		MQT 17 Hail (75mm)	Pass
		MQT 01 Visual Inspection	Pass
		MQT 06.1 Performance at STC	350.01 W (-0.89% Pmp Change)
24028-002	MIT24A00262	MQT 01 Visual Inspection	Pass
		MQT 06.1 Performance at STC	353.71 W
		MQT 17 Hail (65mm)	Pass
		MQT 01 Visual Inspection	Pass
		MQT 06.1 Performance at STC	353.13 W (-0.16% Pmp Change)
24028-003	MIT24A00244	MQT 01 Visual Inspection	Pass
		MQT 06.1 Performance at STC	352.44 W
		MQT 17 Hail (55mm)	Pass
		MQT 01 Visual Inspection	Pass
		MQT 06.1 Performance at STC	350.47 W (-0.56% Pmp Change)

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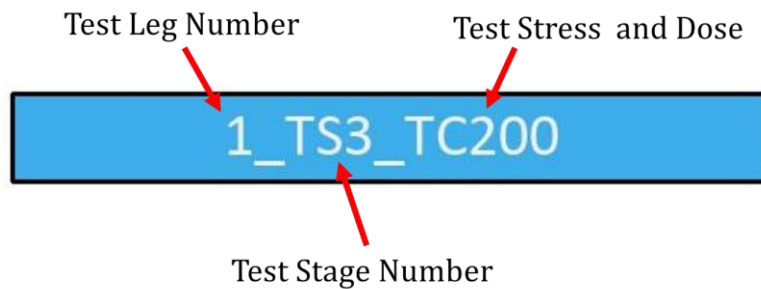
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Test Flow

The figure below shows the test flow for this project.

Seq0 Incoming Inspection	Seq 1 Hail
3 Samples	3 Samples
0_TSO_Initial	1_TSO_Hail
Incoming Inspection	EL Imaging 1.0x Isc
MQT 01 Visual Inspection - 2021	MQT 06.1 Perf at STC-V1 - 2021 - Front
	1_TS1_Hail
	MQT 17 Hail - 2021
	MQT 01 Visual Inspection - 2021
	EL Imaging 1.0x Isc
	MQT 06.1 Perf at STC-V1 - 2021 - Front

In the diagram above the test flow is divided into columns, which are referred to as “test legs”. Each test leg is graphically displayed under the dark blue title blocks with comments in the gray block under the title block. Within each test leg, individual tests are displayed as white blocks. Tests are divided into groups, named “references”. References are displayed as light blue blocks. References are used to separate and identify results that are performed at different stages of testing (see below).



Test Stress and Dose sums based on the Test Stage Number. For example, 1_TS3_TC200 stipulates that in Test Leg 1, 200 cycles of Thermal Cycling were applied in Test Stage Number 3. If that is followed by 1_TS4_TC200, another 200 cycles were applied, summing to 400 total thermal cycles that have been applied by TS4.

Results

Incoming Inspection

No issues were observed on the test modules during the Incoming Inspection. An Incoming Inspection report is provided separately.

MQT 01 Visual Inspection

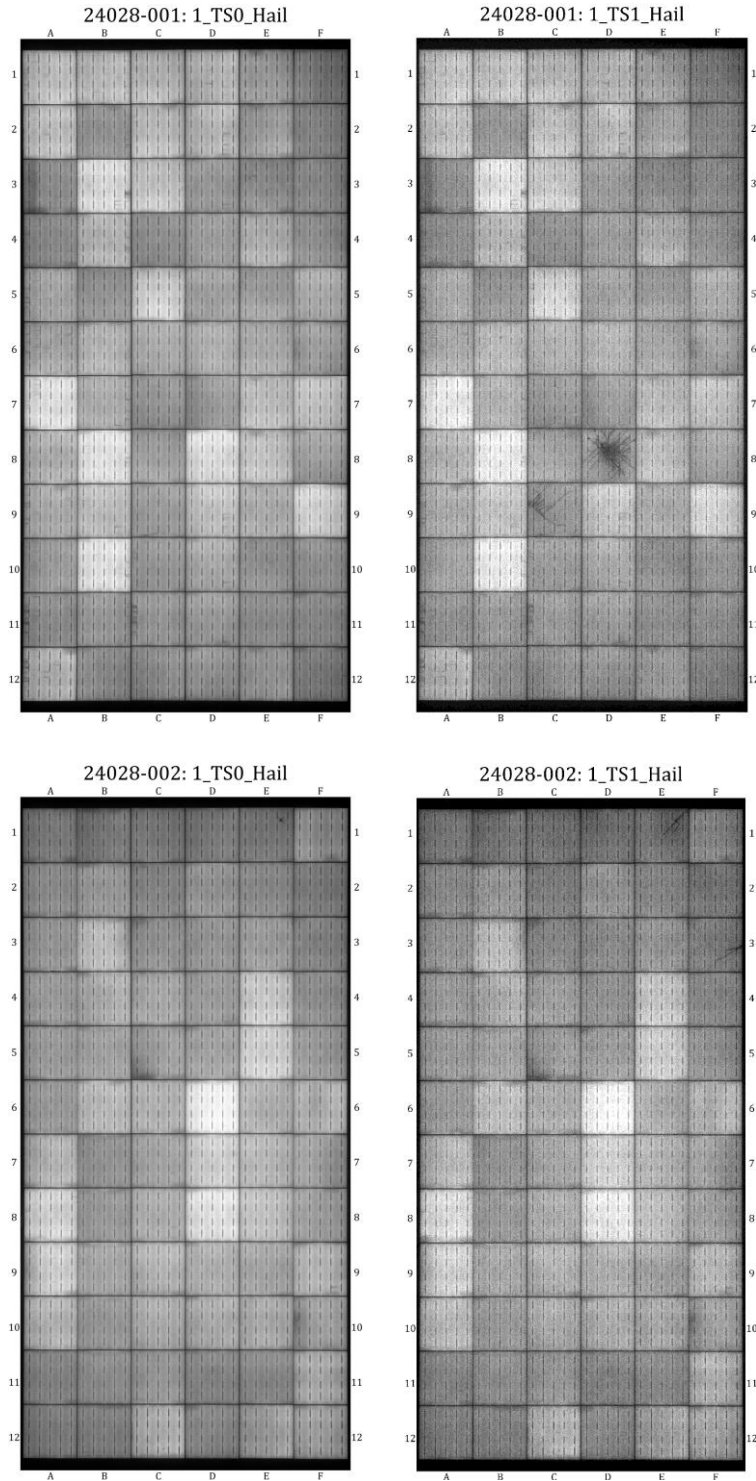
The results of the visual inspection are summarized in the table below. The presence of any of the following observations constitutes a major visual defect:

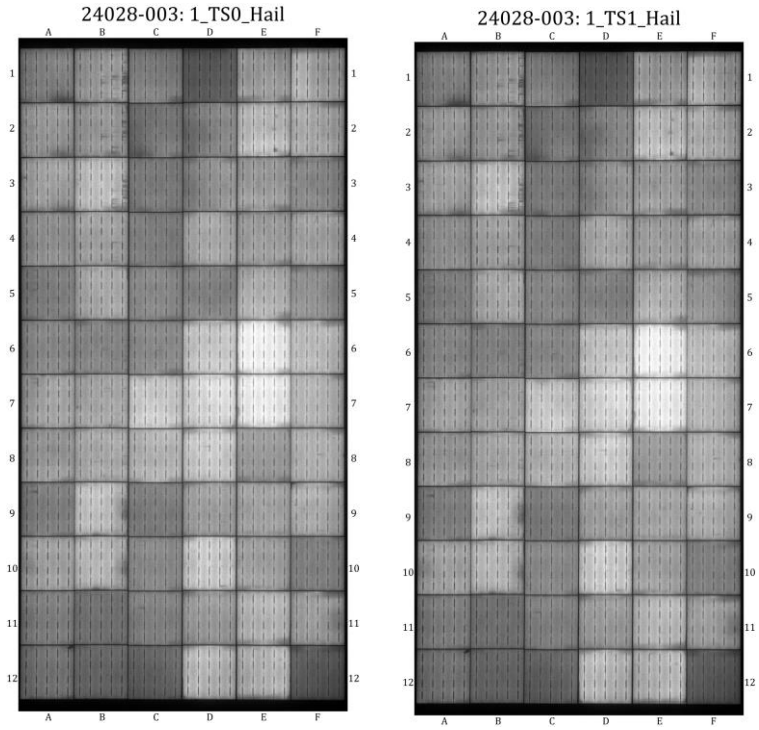
1. Broken, cracked, or torn external surfaces.
2. Bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the operation of the PV module would be impaired.
3. Bubbles or delaminations forming a continuous path between electric circuit and the edge of the module.
4. If the mechanical integrity depends on lamination or other means of adhesion, the sum of the area of all bubbles shall not exceed 1 % of the total module area.
5. Evidence of any molten or burned encapsulant, backsheet, frontsheet, diode or active PV component.
6. Loss of mechanical integrity to the extent that the installation and operation of the module would be impaired.
7. Cracked/broken cells which can remove more than 10 % of the cell's photovoltaic active area from the electrical circuit of the PV module.
8. Voids in, or visible corrosion of any of the layers of the active (live) circuitry of the module extending over more than 10 % of any cell.
9. Broken interconnections, joints or terminals.
10. Any short-circuited live parts or exposed live electrical parts.
11. Module markings (label) are no longer attached, or the information is unreadable.

No major visual defects were observed during the visual inspection of the tested modules.

Module ID	Reference	Major Defect Found?	Defect	Comments
24028-001	0_TS0_Initial	No	-	-
	1_TS1_Hail	No	-	-
24028-002	0_TS0_Initial	No	-	-
	1_TS1_Hail	No	-	-
24028-003	0_TS0_Initial	No	-	-
	1_TS1_Hail	No	-	-

Electroluminescence (EL) Imaging – 1.0xIsc





MQT 06.1 Performance at STC

Estimated Measurement Uncertainty

Technology	Isc	Voc	Imp	Vmp	Pmp
Si, Monofacial (k=2)	±1.4%	±0.7%	±1.8	±1.2	±1.9

Front-side Measurements (1000 W/m², 25 °C):

Module ID	Reference	Isc [A]	Voc [V]	Imp [A]	Vmp [V]	Pmp [W]	FF [%]
24028-001	1_TS0_Hail	9.406	48.58	8.935	39.52	353.15	77.29
	1_TS1_Hail	9.381	48.47	8.874	39.44	350.01	76.98
24028-002	1_TS0_Hail	9.400	48.54	8.912	39.69	353.71	77.52
	1_TS1_Hail	9.393	48.50	8.922	39.58	353.13	77.53
24028-003	1_TS0_Hail	9.385	48.62	8.910	39.56	352.44	77.25
	1_TS1_Hail	9.390	48.57	8.887	39.44	350.47	76.85

Front-side Change from Baseline:

Module ID	Reference	ΔIsc [%]	ΔVoc [%]	ΔImp [%]	ΔVmp [%]	ΔPmp [%]
24028-001	1_TS0_Hail	+0.00	+0.00	+0.00	+0.00	+0.00
	1_TS1_Hail	-0.27	-0.23	-0.69	-0.21	-0.89
24028-002	1_TS0_Hail	+0.00	+0.00	+0.00	+0.00	+0.00
	1_TS1_Hail	-0.08	-0.10	0.11	-0.28	-0.16
24028-003	1_TS0_Hail	+0.00	+0.00	+0.00	+0.00	+0.00
	1_TS1_Hail	+0.06	-0.11	-0.26	-0.30	-0.56

MQT 17 Hail

CFV Labs conducted hail testing using a pneumatic hail launcher (shown below).



The customer specified a test hail size of 55mm, 65mm and 75mm, mounted in accordance with the module installation document provided by the manufacturer. Four bolts were drilled into the preinstalled anchor plates on a Z-bar provided by the customer. The module mounting and hail impact locations are pictured below.

24028-003 (55mm)



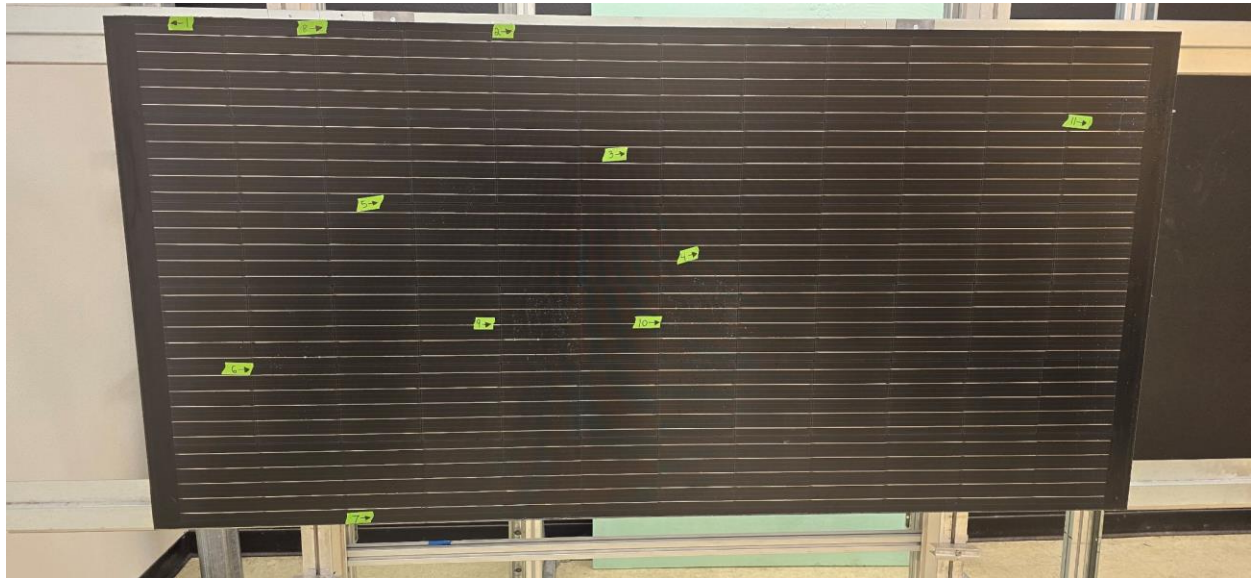
Shot	Impact Location	Result	Ice Ball Weight (g)	Ice Ball Velocity (m/s)
1	Module Corner	Pass	78.17	33.97
2	Module Edge	Pass	78.55	33.69
3	Interconnects	Pass	76.24	33.69
4	Interconnects	Pass	77.59	34.25
5	Circuit Edge	Pass	77.94	33.97
6	Circuit Edge	Pass	76.95	33.78
7	Mounting Points	Pass	77.46	33.78
8	Mounting Points	Pass	77.97	34.15
9	Module Center	Pass	77.34	33.51
10	Module Center	Pass	77.26	33.69
11	Junction box	Pass	77.16	33.78
Overall Result		Pass		

24028-002 (65mm)



Shot	Impact Location	Result	Ice Ball Weight (g)	Ice Ball Velocity (m/s)
1	Module Corner	Pass	126.24	36.02
2	Module Edge	Pass	126.74	36.44
3	Interconnects	Pass	125.56	35.92
4	Interconnects	Pass	126.51	35.71
5	Circuit Edge	Pass	128.51	36.87
6	Circuit Edge	Pass	130.56	37.65
7	Mounting Points	Pass	128.14	37.09
8	Mounting Points	Pass	129.77	36.98
9	Module Center	Pass	126.37	36.34
10	Module Center	Pass	128.85	35.82
11	Junction box	Pass	128.55	36.87
Overall Result		Pass		

24028-001 (75mm)



Shot	Impact Location	Result	Ice Ball Weight (g)	Ice Ball Velocity (m/s)
1	Module Corner	Pass	198.74	38.94
2	Module Edge	Pass	194.38	38.70
3	Interconnects	Pass	195.29	38.94
4	Interconnects	Pass	193.76	39.06
5	Circuit Edge	Pass	196.88	39.94
6	Circuit Edge	Pass	194.23	39.06
7	Mounting Points	Pass	194.07	39.56
8	Mounting Points	Pass	193.22	38.46
9	Module Center	Pass	195.80	39.94
10	Module Center	Pass	194.17	39.06
11	Junction box	Pass	197.27	40.19
Overall Result		Pass		

Sample Information

Labeling:

Module ID	Manufacturer	Model	Serial Number
24028-001	Mitrex	M355-CL01F612	MIT24A00245

Construction Details:

Module Type	Manufacturer	Length [m]	Width [m]	Thickness [mm]
M355-CL01F612	Mitrex	2.030	0.992	58

Nameplate Values:

Module Type	Isc [A]	Voc [V]	Imp [A]	Vmp [V]	Pmp [W]	Max Sys Volt [V]	Fuse Rating [A]
M355-CL01F612	9.58	48.7	9.07	40.2	364.3	1000	20

Front View



Back View



Connector 1



Connector 2



Module Sideview



Nameplate



Procedures

The procedures are summarized in the following table.

Test Name	Standard / Procedure
Incoming Inspection	CFV
MQT 01 Visual Inspection	IEC 61215-2:2021
EL Imaging 1.0x Isc	IEC 60904-13:2018
MQT 06.1 Performance at STC	IEC 61215-2:2021
MQT 15 Wet Leakage Current	IEC 61215-2:2021
MQT 17 Hail	IEC 61215-2:2021

Equipment and Calibration

Equipment and calibration information is available upon request.

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