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WIND PRESSURE TESTING OF PHONO SOLAR PANEL MODELS: PSXXXL12GFH-16/QSH; (SOLAR PHOTOVOLTAIC MODULES)

ACE REFERENCE: 24-0205.01, REV: 02

Date of Issue: 18th July 2024

SUMEC Australia Phono Solar
Attention: Bonnie Jiang
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Address: TBC

**RE: Phono Solar Panel Modules, PSXXXL12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg;
Models: PS440L12GFH-16/QSH; PS445L12GFH-16/QSH; PS450L12GFH-16/QSH; PS455L12GFH-16/QSH & PS460L12GFH-16/QSH, with 2 Supports at 800 mm, 2 Supports at 1200 mm Centres & 3 Supports at 600 mm**

This Test Report certifies the Recommended Design Wind Pressure(s) for the above mentioned Phono Solar Panel Modules. This Test Report is for the testing of the PV Module Frames only, and does not cover the supporting elements/ rails and or associated fixings of the tested panels to the supporting elements/ rails.

This Report verifies that the PV Modules are capable of withstanding the Design Wind Loads when installed to an approved railing system with the corresponding support points as listed in Table 1.

Albright Consulting Engineers (ACE) Pty Ltd were engaged by SUMEC Australia Phono Solar to carry out and witness 6 individual mechanical load tests (simulated static, wind load strength test). The testing was performed on new panels supplied by SUMEC Australia Phono Solar.

A total of 6 individual panels were tested. The following tests were carried out:

- Test Scope 1: 3 individual test samples with 2 supports/ clamps at 800 mm centres;
- Test Scope 2: 3 individual test samples with 2 supports/ clamps at 1200 mm centres;

The solar panel module(s) were mounted front side up using fixing clamps and brackets, which are then bolted to the test bed chassis. This is was to imitate a real-world situation; (this process was repeated for each test sample).

A constant pressure/ load was applied by an airbag located the back of the panel. A calibrated digital manometer was used to measure and track the design test pressures, while a calibrated digital deflection meter was used to measure and record the centre (vertical) deflection of the solar panel at 1kPa intervals. The electrical continuity or the cells themselves were not monitored during each of the tests.

Note that a mechanical load testing and or simulated static, wind load strength testing was carried out for the above-mentioned solar panel module samples and the support fixing configuration(s). The testing procedure that was adopted is generally accordance to the methods outlined in AS4040 (series), Static Strength Test Regime.

The 6 individual simulated static, wind load strength tests were conducted and observed by Nicholas Kastellorizios a representative of Albright Consulting Engineers in Darwin Northern Territory, on the 17th June 2024. The behaviour of the modules was observed and recorded.

Material Variability Factor AS/NZS 1170.0, Table B1 – kt:

The applied factor for variability for 1 individual test sample (1 individual units tested per support centre) and adopting a coefficient of variation of structural characteristics of 10% in accordance with AS/NZS 1170.0, Table B1 (when determining the allowable design capacity) is 1.46.

The applied factor for variability for 2 individual test samples (2 individual units tested per support centre) and adopting a coefficient of variation of structural characteristics of 10% in accordance with AS/NZS 1170.0, Table B1 (when determining the allowable design capacity) is 1.38.

The applied factor for variability for 3 individual test samples (3 individual units tested per support centre) and adopting a coefficient of variation of structural characteristics of 10% in accordance with AS/NZS 1170.0, Table B1 (when determining the allowable design capacity) is 1.33.

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Results & Observations:

Test No.1, x3 Samples, Phono Solar Panel Modules: PS440L12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg, with 2 Supports at 800 mm Centres. Serial Numbers: PSQHSM04197210524; PSQHSM02227210524 & PSQHSM03177210524

The above mentioned solar panel samples were mounted to the test rig with 2 supports at **800 mm** centres apart on each side with a cantilever/ overhang of approximately **481 mm** at each end.

During all three individual tests, the solar panel modules were observed to be able to support an equivalent design test pressure of **6.0 kPa**, with a centre vertical deflection **84.6 mm** (approximately).

While attempting to increase the design test pressure(s), the solar panels failed/ shattered at approximately **6.5 kPa**.

These results were recorded just as the solar panel module frames failed/buckled, causing the glass front face to shatter. Note there were very consistent results and observations during all three tests.

It was observed that during each test, as the test pressure was increased, the top flanges of longer rail framing elements appeared to roll inwards. This rolling or torsional effect caused concentrated pressures to form along the top (glass) face of the panel. This was more evident at the clamping zones of the panel, as localised indentations to the rail as well as radial cracking at the glass front face were both observed after it failed (shattered).

The shorter rail elements buckled in an arch like manner. These high deflections coupled with the high pressures to the top of the glass caused the panels to fail. This is likely due to a thinner (30mm) frame as well as the changes to the section properties to the shorter framing elements, refer to note below.

It was also observed that during all tests, the solar panel modules buckled due to the excessive deflections, thus curving the panel frame upwards in an arch like shape. Thus causing the frame to fail, resulting in the failure of the glass front face.

The glass front face of the solar panel modules shattered and cracked; with visually obvious signs of major structural fatigue occurring at the shorter framing elements of the solar panel module. This indicated that the frames had yielded/ entered into the plastic phase of the material. Note that it was observed that the front glass face appears to be thinner when compared with previous models.

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Results & Observations:

Test No.2, x3 Samples, Phono Solar Panel Modules: PS440L12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg, with 2 Supports at 1200 mm Centres. Serial Numbers: PSQHSM05137210524; PSQHSM04637210524 & PSQHSM07137210524

The above mentioned solar panel samples were mounted to the test rig with 2 supports at **1200 mm** centres apart on each side with a cantilever/ overhang of approximately **281 mm** at each end.

During all three individual tests, the solar panel modules were observed to be able to support an equivalent design test pressure of **4.5 kPa**, with a centre vertical deflection **55.4 mm** (approximately).

While attempting to increase the design test pressure(s), the solar panels failed/ shattered at approximately **5.0 kPa**.

These results were recorded just as the solar panel module frames failed/buckled, causing the glass front face to shatter. Note there were very consistent results and observations during all three tests.

It was observed that during each test, as the test pressure was increased, the top flanges of longer rail framing elements appeared to roll inwards. This rolling or torsional effect caused concentrated pressures to form along the top (glass) face of the panel. This was more evident at the clamping zones of the panel, as localised indentations to the rail as well as radial cracking at the glass front face were both observed after it failed (shattered).

The shorter rail elements buckled in an arch like manner. These high deflections coupled with the high pressures to the top of the glass caused the panels to fail. This is likely due to a thinner (30mm) frame as well as the changes to the section properties to the shorter framing elements, refer to note below.

It was also observed that during all tests, the solar panel modules buckled due to the excessive deflections, thus curving the panel frame upwards in an arch like shape. Thus causing the frame to fail, resulting in the failure of the glass front face.

The glass front face of the solar panel modules shattered and cracked; with visually obvious signs of major structural fatigue occurring at the shorter framing elements of the solar panel module. This indicated that the frames had yielded/ entered into the plastic phase of the material. Note that it was observed that the front glass face appears to be thinner when compared with previous models.

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Results & Observations:

Test No.3, x3 Samples, Phono Solar Panel Modules: PS440L12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg, with 3 Supports at 600 mm Centres. Serial Numbers: PSQHSM00327210524; PSQHSM06907210524 & PSQHSM070277210524

The above mentioned solar panel samples were mounted to the test rig with 3 supports at **600 mm** centres apart on each side with a cantilever/ overhang of approximately **281 mm** at each end.

During all three individual tests, the solar panel modules were observed to be able to support an equivalent design test pressure of **4.5 kPa**, with a centre vertical deflection **52 mm** (approximately).

While attempting to increase the design test pressure(s), the solar panels failed/ shattered at approximately **5.0 kPa**.

These results were recorded just as the solar panel module frames failed/buckled, causing the glass front face to shatter. Note there were very consistent results and observations during all three tests.

It was observed that during each test, as the test pressure was increased, the top flanges of longer rail framing elements appeared to roll inwards. This rolling or torsional effect caused concentrated pressures to form along the top (glass) face of the panel. This was more evident at the clamping zones of the panel, as localised indentations to the rail as well as radial cracking at the glass front face were both observed after it failed (shattered).

The shorter rail elements buckled in an arch like manner. These high deflections coupled with the high pressures to the top of the glass caused the panels to fail. This is likely due to a thinner (30mm) frame as well as the changes to the section properties to the shorter framing elements, refer to note below.

It was also observed that during all tests, the solar panel modules buckled due to the excessive deflections, thus curving the panel frame upwards in an arch like shape. Thus causing the frame to fail, resulting in the failure of the glass front face.

The glass front face of the solar panel modules shattered and cracked; with visually obvious signs of major structural fatigue occurring at the shorter framing elements of the solar panel module. This indicated that the frames had yielded/ entered into the plastic phase of the material. Note that it was observed that the front glass face appears to be thinner when compared with previous models.

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Other Observations:

In our opinion the changes to the physical geometry of the solar panel modules is a major contributing factor to the overall failure and performance of the panel, i.e., the grade of aluminium; the depth of the frame being 30 mm, as well as the length of the shorter rails being wider at 1134 mm.

The reductions in capacities when compared to other models tested previously are likely due to the overall system not being as stiff or robust as previous models. Previous models had deeper framing elements with 40mm to 45mm thicker framing and glass elements, with wider flanges to all framing elements, and were also narrower (approx. 990mm), which provided an overall stiffer system, giving them the ability to resist these concentrated localised pressures at the clamping zones, as well as at the corners of the frame.

Other likely factors that may have contributed to the failure or affected performance of these panels include:

1. Thickness & Grade of Glass Face;
2. Thickness of Backing Material;
3. Grade of Aluminium used in the manufacturer of the Frame;
4. Alternative framing elements, some rails do not have flanges, only a thin narrow box sections;
5. Inner Frame Connections/ Junctions;
6. Glass Supports within Frame;
7. Lack of and or quality of Adhesive of between the rails & Sheeting Layers.
8. Packing. Transport and Handling of Samples.

Important Note/ Observation: PSXXXL12GFH-16/QSH

During the testing of these particular solar panel modules, it was observed that there was a significantly different failure mechanism occurring; this was in addition to the aforementioned observations above.

There is an earth clamp bolt penetration punched at the centre of the bottom flange on both the shorter framing rail elements. This bottom flange is fundamentally critical to the overall stiffness of the module. Like any beam that is simply supported and subjected to a uniform distributed load; the maximum bending stresses are invoked are at the centre of the beam. It is the flanges of the beam that provide the resistance to these bending stresses.

Thus the bottom flanges resists/ undergoes high compressive bending forces/ stresses when subjected to the test the pressures in much the same way.

After each test it was observed that both flanges of the shorter framing elements severely buckled in an upwards direction at the mid span where the penetrations are located.

The earth clamp bolting penetrations appear to have affected the capacity of the overall framing system as the shorter framing elements buckled up sharply causing the front glass face to fail. We therefore recommend that the small penetrations are moved from the centre of the bottom flange to either the far side and like other modules.

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Table 1: Test Summary: Recommended Ultimate Design Strength, Limit Design Capacity

Test	Panel Manufacturer, Model & Size (mm)	Support Centres (mm)	Maximum Applied Load (kPa)	Material Variability Factor AS/NZS 1170.0 Table B1 – kt	Recommended Ultimate Design Strength Limit State Design Capacity (kPa)
No.1	X3 Samples: Phono Solar Panel Modules: PS440L12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg	2 Supports at 800mm	6.0	1.33	4.51
No.2	X3 Samples: Phono Solar Panel Modules: PS440L12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg	2 Supports at 1200mm	4.5	1.33	3.38
No.3	X3 Samples: Phono Solar Panel Modules: PS440L12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg	3 Supports at 600mm	4.5	1.33	3.38

Note that the above mentioned Recommended Ultimate Design Strength, Limit Design Capacities are only applicable to the models & power series stated within this certificate, as well as listed on the attached data sheet.

Note that the Project Engineer/ Design Engineer should consider the panel deflection as a design criteria. These deflections could cause the panels to pop/ slip out of the fixing clamps.

Phono Solar Panel Modules, PSXXXL12GFH-16/QSH, Mechanical Properties:

Cell Type:	HJT Monocrystalline
Cells:	No Data Provided
Dimensions:	1762 mm x 1134 mm x 30 mm
Weight:	22.0 kg
Junction Box:	IP68
Backing Material/ Substrate:	1.6 mm Tempered Glass
Front Material/ Superstrate:	1.6 mm Tempered Glass
Frame:	30 mm Black Anodized Aluminium Frame

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Summary:

We recommended and verify that the **Phono Solar Panel Modules, PSXXXL12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg; Models: PS440L12GFH-16/QSH; PS445L12GFH-16/QSH; PS450L12GFH-16/QSH; PS455L12GFH-16/QSH & PS460L12GFH-16/QSH**, Solar Panel Modules can resist the following vertical design loads, with a Recommended Ultimate Design Strength (Limit State Design Capacity), as listed for the following support conditions:

- **Supported on purlins/ battens, 2 supports/ rails at 800 mm centres: 4.51 kPa;**
- **Supported on purlins/ battens, 2 supports/ rails at 1200 mm centres: 3.38 kPa;**
- **Supported on purlins/ battens, 3 supports/ rails at 600 mm centres: 3.38 kPa;**

This Report has been prepared on behalf of and for the exclusive use of SUMEC Australia Phono Solar and is for the testing of the PV Module Frame only; and **not** the supporting elements, clamps, rails and or associated fixings of the PV Modules to the rails.

The Recommended Ultimate Design Strength, Limit State Design Capacities, (kPa) are only applicable for the panel model; size, weight and support/ rail spacing's as the above-mentioned tested model(s). Any additional power output models referenced may also be covered under this certificate provided that they are referenced in the same technical datasheet (attached); are mechanically & physically identical to the (tested): **Phono Solar Panel Modules: PS440L12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg;** and that they are manufactured in the exact same way with the exact same materials as the (tested): **Phono Solar Panel Modules: PS440L12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg.** Refer to Appendix A for datasheet.

This certificate and certification is no longer valid if:

1. If any of the Engineering & Mechanical Properties used in the manufacture of the solar panel modules/ models is altered or changed in any way to the above mentioned tested solar panel modules/ models.
2. If any of the manufacturing processes or techniques used in the manufacture of the solar panel modules/ models is altered or changed in any way to the above mentioned tested solar panel modules/ models.
3. It is the responsibility of the manufacturer to confirm if there has been any alterations, changes or revisions to the physical makeup of the frame, i.e. aluminium grade, front glass face or backing sheet, etc.; or if the manufacturing process has altered or changed in any way, re-testing may be required.
4. This certificate is rendered invalid if any changes have occurred to the tested modules/ models as noted above.

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Important Notes:

1. Note that the deflection criteria of the panels themselves may govern or limit the structural design and should be considered in high design wind pressure zones; as excessive deflections may cause the panel's to slip and or pop out from the fixing clamps.
2. The panel fixing clamps; the support rails; their associated fixings or the fixings of the L Feet to the immediate supporting structure, were not tested as part of the test procedure/ scope, and therefore no comment can be made as to their role as a potential failure mode. Note that these elements must be individually evaluated and confirmed by the Project Engineer and or the Design Engineer, as they may limit the structural design or capacity of the total structural system.
3. The railing system is excluded from this certification and is designed & certified by others.
4. The immediate supporting elements for the PV Roof Mounted Solar Panel System is also excluded from this certification and is designed & certified by others.
5. This Report verifies the Design Wind Pressures for the above referenced Solar Panel Modules/ Modes. However, they are subject to the analysis and approval by the Project Engineer; Design Engineer and or Approved Competent Person on a project by project basis. Note that the Design Engineer must confirm that the Design Wind Pressures are less than the Recommend Capacities referenced within this report, for each specific project.

Company Name if certification issued on behalf of a corporation Albright Services Group Pty Ltd, Trading as Albright Consulting Engineers		Company NT Registration Number 215037ES	
I certify that reasonable care has been taken to ensure that the structural engineering aspects of the works as described above have been designed in accordance with the requirements of the Building Code of Australia and the Northern Territory Building Regulations			
Name Nicholas Kastellorizios Nominee for Albright Services Group Pty Ltd, Trading as Albright Consulting Engineers	Nominee/Individual NT Registration Number 215037ES	Signature 	Date 18/07/2024

Please contact our office if you require any further information in relation to this report.

Nicholas Kastellorizios
Director/ Structural Engineer
Albright Consulting Engineers

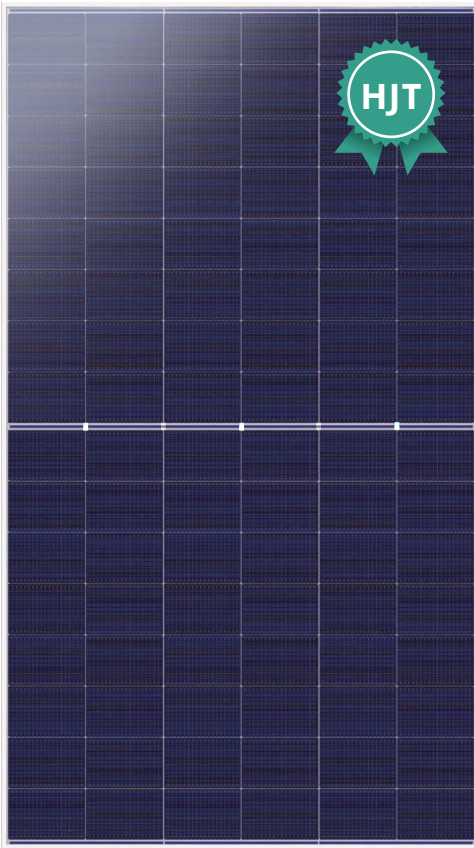


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Appendix:

Phono Solar Panel Modules, PSXXXL12GFH-16/QSH, 1762 mm x 1134 mm x 30 mm, 22.0 kg;
Models: PS440L12GFH-16/QSH; PS445L12GFH-16/QSH; PS450L12GFH-16/QSH; PS455L12GFH-16/QSH & PS460L12GFH-16/QSH



440-460w

Helios Module Series

N-HJT HIGH EFFICIENCY MONO BL8-18B-G

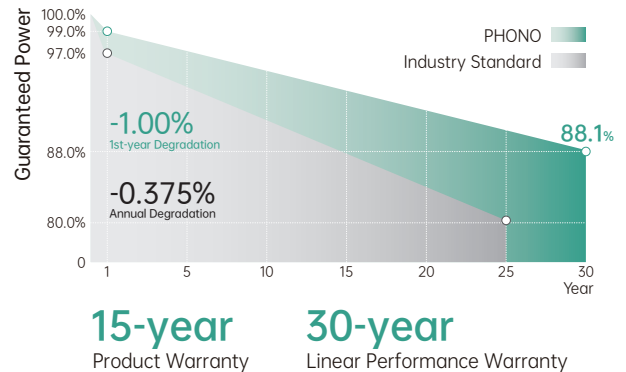
Bloomberg
NEW ENERGY FINANCE

Tier1



Excellent Power Generation Performance

- Optimized cell size brings higher power
- Over 85% bifaciality and up to 30% additional power generation
- Competitive high-temperature performance with ameliorated temperature coefficient ($-0.24\%/^{\circ}\text{C}$)
- Better weak illumination response of HJT technology leads higher power generation



Higher Quality Reliability

- N-type with lower LID and LeTID
- Industry-leading cell technology of TCO thin film contributes to excellent anti-PID characteristic
- Sealing with PIB based sealant to achieve stronger water resistance, greater air impermeability and longer module lifespan

More Environmentally Friendly

- Low temperature welding technology & shorter manufacturing process contributes to lower carbon emissions

MANAGEMENT SYSTEM CERTIFICATES

IEC 61215, IEC 61730

ISO 9001
2015 / Quality management system

ISO 14001
2015 / Standards for environmental management system

ISO 45001
2018 / International standards for occupational health & safety

Electrical Typical Values

Model	1000V	PS440L12GF-16/QSH		PS445L12GF-16/QSH		PS450L12GF-16/QSH		PS455L12GF-16/QSH		PS460L12GF-16/QSH	
	1500V	PS440L12GFH-16/QSH		PS445L12GFH-16/QSH		PS450L12GFH-16/QSH		PS455L12GFH-16/QSH		PS460L12GFH-16/QSH	
Testing Condition		STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Rated Power (Pmpp)		440	337	445	341	450	345	455	349	460	352
Rated Current (Impp)		14.49	11.59	14.59	11.67	14.68	11.74	14.77	11.82	14.86	11.89
Rated Voltage (Vmpp)		30.37	29.08	30.52	29.20	30.66	29.35	30.81	29.50	30.96	29.64
Short Circuit Current (Isc)		15.19	12.15	15.29	12.23	15.38	12.30	15.47	12.38	15.57	12.46
Open Circuit Voltage (Voc)		36.18	34.66	36.34	34.81	36.50	34.97	36.66	35.12	36.82	35.27
Module Efficiency (%)		22.02		22.27		22.52		22.77		23.02	

STC (Standard Testing Conditions): Irradiance 1000W/m², AM 1.5, Cell Temperature 25°C

NOCT (Nominal Operation Cell Temperature): Irradiance 800W/m², Ambient Temperature 20°C, Spectra at AM1.5, Wind at 1m/s

Made in China.Measurement Tolerance at STC:Pmax±3%,Voc±3% and isc±4%

BSTC

Maximum Power (Pmax)	490	496	501	507	512
Optimum Operating Current (Impp)	16.10	16.20	16.30	16.41	16.50
Optimum Operating Voltage (Vmpp)	30.47	30.62	30.77	30.92	31.07
Short Circuit Current (Isc)	16.94	17.04	17.15	17.25	17.35
Open Circuit Voltage (Voc)	36.31	36.47	36.63	36.79	36.95

BSTC:Front Side Irradiation 1000W/m², Back Side Reflection Irradiation 135W/m², AM 1.5, Ambient Temperature 25°C

Mechanical Characteristics

Cell Type	HJT Monocrystalline
Dimension (L × W × H)	Length: 1762mm (69.37 inch) Width: 1134mm (44.65 inch) Height: 30mm (1.18 inch)
Weight	22.0kg (48.50 lbs)
Glass	1.6mm/1.6mm toughened glass
Frame	Anodized Aluminium Alloy
Cable (Including Connector)	4mm ² (IEC), 300mm or Customized Length
Junction Box	IP 68 Rated, Staubli EV02

Temperature Ratings

Voltage Temperature Coefficient	-0.22%/°C
Current Temperature Coefficient	+0.04%/°C
Power Temperature Coefficient	-0.24%/°C
Power Tolerance	0~+3%
NOCT	44±2°C
Bifaciality	85±5%

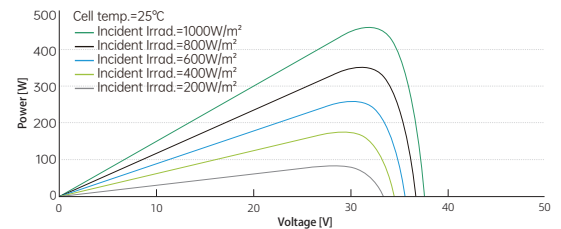
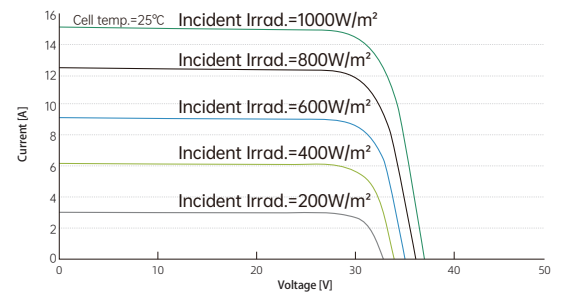
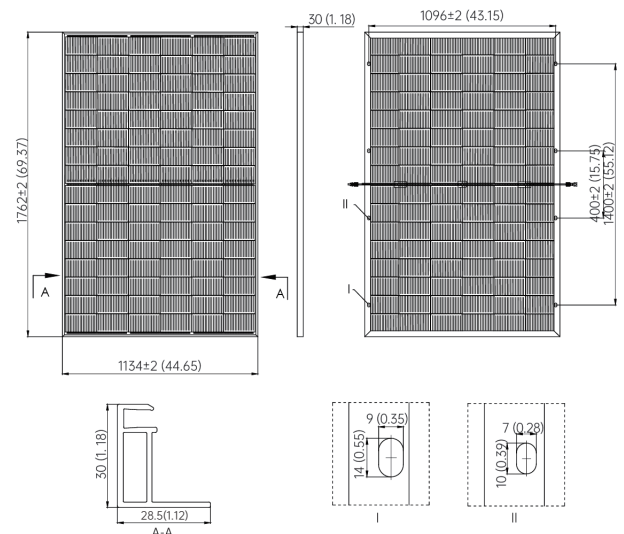
Absolute Maximum Rating

Operating Temperature	From -40 to + 85°C
Hail Diameter @ 80km/h	Up to 25mm
Front Side Maximum Static Loading	5400Pa
Rear Side Maximum Static Loading	2400Pa
Maximum Series Fuse Rating	30A
PV Module Classification	II
Fire Rating (IEC 61730)	C
Maximum System Voltage	DC 1000V/1500V

Packing Configuration

Container	40' HQ
Pieces/Container	936
Pcs/Pallet	36
Pallets/Container	26

Electrical Characteristics



Note:mm (inch)