ALBRIGHT
CONSULTING ENGINEERS

Address: PO BOX 4321, PALMERSTON, NT 0831
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WIND PRESSURE TESTING OF TRINA SOLAR PANEL MODELS: TSM-XXXNEG18R.28/20; (SOLAR PHOTOVOLTAIC MODULES)

ACE REFERENCE: 24-0221.01**,** REV: 01

Date of Issue: 18th July 2024

Trina Solar Australia Pty. Ltd
Attention: Andrew Zhai
Mob: 0426 796 866
Email: andrew.zhai@trinasolar.com
Address: UG, 2 Banfield Rd, Macquarie Park NSW 2113

RE: Trina Solar Panel Modules, TSM-XXXNEG18R.28/20, 1961 mm x 1134 mm x 30mm, 23.5 kg; Models: TSM-475NEG18R.28/20; TSM-480NEG18R.28/20; TSM-485NEG18R.28/20; TSM-490NEG18R.28/20; TSM-495NEG18R.28/20; TSM-500NEG18R.28/20 & TSM-505NEG18R.28/20, with 2 Supports at 1200 mm & 3 Supports at 900 mm

This Test Report certifies the Recommended Design Wind Pressure(s) for the above mentioned Trina 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 Trina Solar Australia Pty. Ltd 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 Trina Solar Australia Pty. Ltd.

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 1200 mm centres;
- Test Scope 2: 3 individual test samples with 3 supports/ clamps at 900 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.

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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 18th July 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.2, x3 Samples, Trina Solar Panel Modules: TSM-475NEG18R.28/20, 1961 mm x 1134 mm x 30mm, 23.5 kg, with 2 Supports at 1200 mm Centres. Serial Numbers: A05240300810017; A05240300809991 & A05240300809583

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 **380.5 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 kPa**, with a centre vertical deflection **82.7 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 to 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 is 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, Trina Solar Panel Modules: TSM-475NEG18R.28/20, 1961 mm x 1134 mm x 30mm, 23.5 kg, with 3 Supports at 900 mm Centres. Serial Numbers: A05240300809382; A05240300809997 & A05240300810026

The above mentioned solar panel samples were mounted to the test rig with 3 supports at **900 mm** centres apart on each side with a cantilever/ overhang of approximately **80.5 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 **5.5 kPa**, with a centre vertical deflection **70 mm** (approximately).

While attempting to increase the design test pressure(s), the solar panels failed/ shattered at approximately **6.0 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 to 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 is 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.

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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: Trina Solar Panel Modules: TSM-475NEG18R.28/20, 1961 mm x 1134 mm x 30mm, 23.5 kg	2 Supports at 1200mm	6.0	1.33	**4.51**
No.2	X3 Samples: Trina Solar Panel Modules: TSM-475NEG18R.28/20, 1961 mm x 1134 mm x 30mm, 23.5 kg	3 Supports at 900mm	5.5	1.33	**4.14**

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.

Trina Solar Panel Modules, TSM-XXXNEG18R.28/20, Mechanical Properties:

Cell Type:	N-Type Monocrystalline
Cells:	108 Cells
Dimensions:	1961 mm x 1134 mm x 30 mm
Weight:	23.5 kg
Junction Box:	IP68
Backing Material/ Substrate:	1.6 mm Heat Strengthened Glass
Front Material/ Superstrate:	1.6 mm High Transmission AR Coated Heat Strengthened Glass
Frame:	30 mm Anodized Aluminium Alloy (.28 Black/ .20 Silver)

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Summary:

We recommended and verify that the **Trina Solar Panel Modules: TSM-XXXNEG18R.28/20, 1961 mm x 1134 mm x 30mm, 23.5 kg; Models: TSM-480NEG18R.28/20; TSM-485NEG18R.28/20; TSM-490NEG18R.28/20; TSM-495NEG18R.28/20; TSM-500NEG18R.28/20 & TSM-505NEG18R.28/20,** 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 1200 mm centres: 4.51 kPa;**
- **Supported on purlins/ battens, 3 supports/ rails at 900 mm centres: 4.14 kPa;**

This Report has been prepared on behalf of and for the exclusive use of Trina Solar Australia Pty. Ltd 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): **Trina Solar Panel Modules: TSM-475NEG18R.28/20, 1961 mm x 1134 mm x 30mm, 23.5 kg**; and that they are manufactured in the exact same way with the exact same materials as the (tested): **Trina Solar Panel Modules: TSM-475NEG18R.28/20, 1961 mm x 1134 mm x 30mm, 23.5 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:

Trina Solar Panel Modules: TSM-XXXNEG18R.28/20, 1961 mm x 1134 mm x 30mm, 23.5 kg; Models: TSM-480NEG18R.28/20; TSM-485NEG18R.28/20; TSM-490NEG18R.28/20; TSM-495NEG18R.28/20; TSM-500NEG18R.28/20 & TSM-505NEG18R.28/20

Vertex N

N-type i-TOPCon Monofacial Dual Glass
MONOCRYSTALLINE MODULE

PRODUCT: TSM-XXXNEG18R.28/.20

PRODUCT RANGE: 475-505W

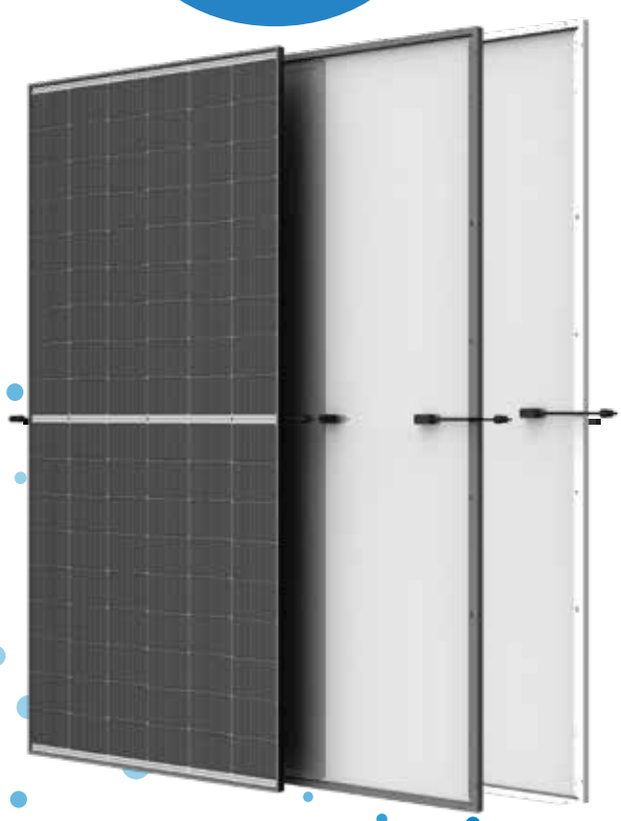
505W
MAXIMUM POWER OUTPUT

0~+5W
BINNING TOLERANCE

22.7%
MAXIMUM EFFICIENCY

15/25 Years PRODUCT WARRANTY

30 Years POWER WARRANTY



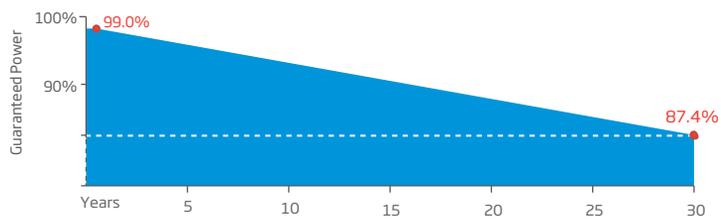
High customer value
- Lower LCOE (levelized cost of energy), reduced BOS (balance of system) cost, shorter payback time
- Designed for compatibility with existing mainstream system components
- High module power, high string power and low voltage design

High power up to 505W
- Up to 22.7% module efficiency with high density interconnect technology
- Multi-busbar technology for better light trapping effect, lower series resistance and improved current collection

Dual-glass design, high reliability
- Less prone to micro-cracks and scratches on the back during installation
- Fire class rating C
- Mechanical performance up to 5400 Pa positive load and 2400 Pa negative load
- Easy to handle and install on roofs with excellent size and light weight

Ultra-low degradation, longer warranty, higher output
- Extremely low 1% first year degradation and 0.4% annual power attenuation
- 15 years product warranty NEG18R.20 (silver frame)
  25 years product warranty NEG18R.28 (black frame)
  and 30 years power warranty
- Lower temperature coefficient (-0.29%/℃) and operating temperature

Trina Solar's Vertex Monofacial Dual Glass Performance Warranty



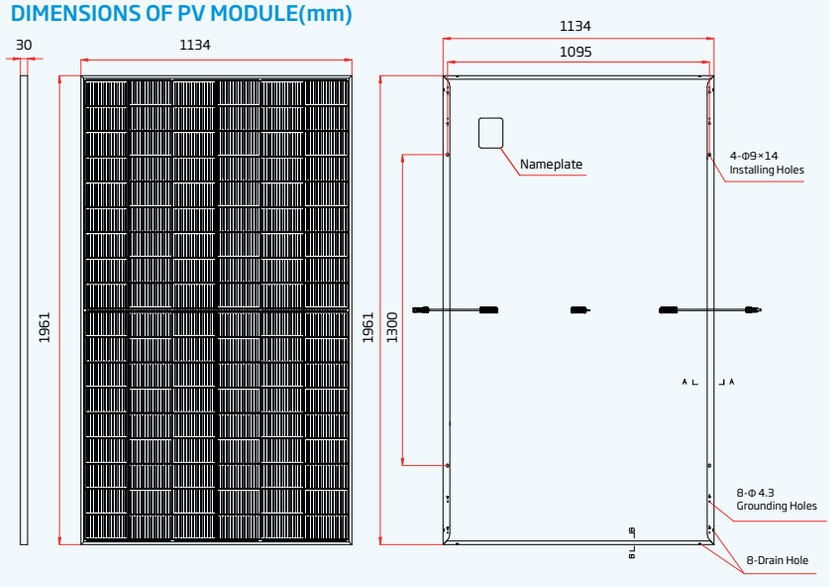
Comprehensive Products and System Certificates

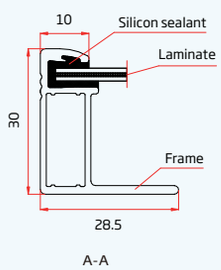
IEC61215/IEC61730
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System

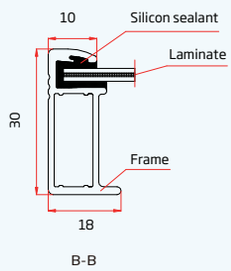
Trinasolar

Vertex N N-type i-TOPCon Monofacial Dual Glass Module

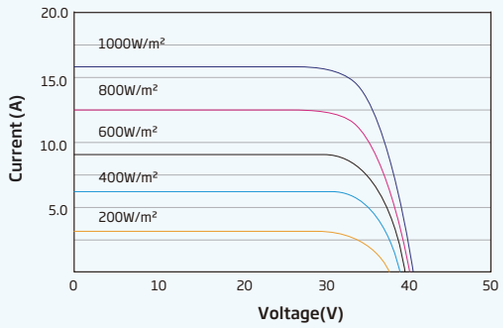
DIMENSIONS OF PV MODULE(mm)



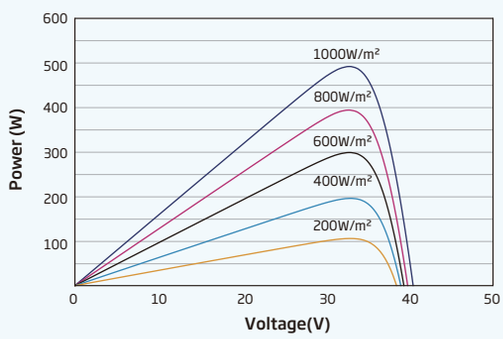




I-V CURVES OF PV MODULE (490W)



P-V CURVES OF PV MODULE (490W)



ELECTRICAL DATA (STC) TSM-XXXNEG18R.28/20(XXX=475-505)

Peak Power Watts-PMAX (Wp)*	475	480	485	490	495	500	505
Binning Tolerance-PMAX (W)	0 ~ +5						
Maximum Power Voltage-VMPP (V)	32.3	32.5	32.7	32.9	33.1	33.3	33.5
Maximum Power Current-IMPP (A)	14.72	14.77	14.84	14.91	14.97	15.03	15.09
Open Circuit Voltage-VOC (V)	39.0	39.2	39.4	39.6	39.8	40.1	40.3
Short Circuit Current-ISC (A)	15.68	15.72	15.76	15.80	15.83	15.86	15.89
Module Efficiency η m (%)	21.4	21.6	21.8	22.0	22.3	22.5	22.7

STC: Irrdiance 1000W/m2, Cell Temperature 25°C, Air Mass AM1.5. *Measuring tolerance: ±3%.

ELECTRICAL DATA (NOCT)

Maximum Power-PMAX (Wp)	363	367	371	375	378	382	386
Maximum Power Voltage-VMPP (V)	30.4	30.6	30.8	31.0	31.3	31.5	31.8
Maximum Power Current-IMPP (A)	11.94	11.98	12.02	12.06	12.08	12.11	12.15
Open Circuit Voltage-VOC (V)	36.9	37.2	37.4	37.6	37.7	38.0	38.3
Short Circuit Current-ISC (A)	12.64	12.67	12.70	12.74	12.76	12.78	12.81

NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

MECHANICAL DATA

Solar Cells	N-type Monocrystalline
No. of cells	108 cells
Module Dimensions	1961×1134×30mm (77.20×44.65×1.18 inches)
Weight	23.5kg (51.8 lb)
Front Glass	1.6mmHigh Transmission, AR Coated Heat Strengthened Glass
Encapsulant material	POE/EVA
Back Glass	1.6mm (0.06 inches), Heat Strengthened Glass
Frame	30mm(0.06 inches) Anodized Aluminium Alloy (.28 black / .20 silver)
J-Box	IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm² (0.006 inches²) Length: 1300mm/1300mm (51.1/51.1 inches)
Connector	Stabuli MC4 EV02

TEMPERATURE RATINGS

NOCT (Nominal Operating Cell Temperature)	43°C (±2°C)
Temperature Coefficient of PMAX	- 0.29%/°C
Temperature Coefficient of VOC	- 0.24%/°C
Temperature Coefficient of ISC	0.04%/°C

MAXIMUM RATINGS

Operational Temperature	-40~+85°C
Maximum System Voltage	1500V DC (IEC)
Max Series Fuse Rating	30A

WARRANTY

15 /25 years Product Workmanship Warranty**

30 year Power Warranty

1% first year degradation

0.4% Annual Power Attenuation

(**Please refer to Limited Warranty Supplement that applies to the TSM-***NEG18R.28,Products installed within Australia & New Zealand rooftop market. TSM-***NEG18R.20 - 15 years product warranty)

PACKAGING CONFIGURATION

Modules per box: 36 pieces

Modules per 40' container: 864 pieces

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

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Version number: TSM_EN_2024_Aus_A
Country of Origin: China

www.trinasolar.com