Address: PO BOX 4321, PALMERSTON, NT 0831
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WIND PRESSURE TESTING OF TOPHiKu6 N-TYPE TOPCON CANADIAN SOLAR PANEL MODELS: CS6R-XXXT; (SOLAR PHOTOVOLTAIC MODULES)

ACE REFERENCE: 23-0124.02**,** REV: 01

Date of Issue: 11th December 2023

Canadian Solar MSS (Australia) Pty Ltd
Attention: Rebecca Hinchliffe & Natalie Morgan
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Address: 333 Drummond Street, Carlton, Victoria, 3053

RE: Canadian Solar Panel Modules,TOPHiKu6 N-TYPE TOPCON: CS6R-420T; CS6R-425T; CS6R-430T; CS6R-435T & CS6R-440T, 1722 mm x 1134 mm x 30 mm, 21.3 kg, with 2 Supports at 800 mm & 2 Supports at 1200 mm Centres

This Test Report certifies the Recommended Design Wind Pressure(s) for the above mentioned TOPHiKu6 Canadian Solar CS6R 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 Canadian Solar MSS (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 Canadian Solar MSS (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 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.

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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 of Albright Consulting Engineers in Darwin Northern Territory, on the 12 December 2023. 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: CS6R-440T, Canadian Solar Panel Modules, 1722 mm x 1134 mm x 30 mm, 21.3 kg, with 2 Supports at 800 mm Centres. Serial Numbers: 12308030221708; 12308030221783 & 12308030221603

The solar panels **(1722 mm x 1134 mm x 30 mm)** were mounted to the test rig with 2 supports at **800 mm** centres apart on each side with a cantilever/ overhang of approximately **461 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 of **86.3 mm** (approximately). While attempting to increase the design test pressure(s), the solar panels failed/ shattered at approximately **7.0 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 were observed at the top glass face before 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.

The reductions in capacities when compared to other models tested previously are likely that the overall system is not 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.

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.

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Test No.2, x3 Samples: CS6R-440T, Canadian Solar Panel Modules, 1722 mm x 1134 mm x 30 mm, 21.3 kg, with 2 Supports at 1200 mm Centres. Serial Numbers: 12308030221819; 12308030221784 & 12308030221634

The solar panels **(1722 mm x 1134 mm x 30 mm)** were mounted to the test rig with 2 supports at **1200 mm** centres apart on each side with a cantilever/ overhang of approximately **261 mm** at each end.

During all individual tests, the solar panel modules were observed to be able to support an equivalent design test pressure of **5.0 kPa**, with a centre vertical deflection **71 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 were observed at the top glass face before 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.

The reductions in capacities when compared to other models tested previously are likely that the overall system is not 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.

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.

ALBRIGHT
CONSULTING ENGINEERS

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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.

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. Different framing elements, some rails do not have flanges, but are only a thin narrow box section;
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.

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: Canadian Solar Panel Modules: CS6R-440T, 1722 mm x 1134 mm x 30 mm, 21.3 kg	2 Supports at 800mm	6.0	1.33	**4.51**
No.2	X3 Samples: Canadian Solar Panel Modules: CS6R-440T, 1722 mm x 1134 mm x 30 mm, 21.3 kg	2 Supports at 1200mm	5.0	1.33	**3.76**

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.

Canadian, CS6R-XXXT, Mechanical Properties:

Cell Type:	Mono-crystalline
Cells:	108 [2x(9x6)]
Dimensions:	1722 mm x 1134 mm x 30 mm
Weight:	21.3 kg
Junction Box:	IP68
Backing Material/ Substrate:	No Data Given
Front Material/ Superstrate:	3.2 mm Tempered Glass With Anti Reflective Coating
Frame:	Anodized Aluminium Alloy

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Summary:

We recommended and certify that the **Canadian Solar TOPHiKu6 N-TYPE TOPCON: CS6R-420T; CS6R-425T; CS6R-430T; CS6R-435T & CS6R-440T, 1722 mm x 1134 mm x 30 mm, 21.3 kg,** 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: 3.76 kPa**

This Report has been prepared on behalf of and for the exclusive use of Canadian Solar MSS (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): **Canadian Solar Panel Module: CS6R-440T, 1722 mm x 1134 mm x 30 mm, 21.3 kg**; and that they are manufactured in the exact same way with the exact same materials as the (tested): **Canadian Solar Panel Module: CS6R-440T, 1722 mm x 1134 mm x 30 mm, 21.3 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.

<table>
<tr><td colspan="2">Company Name if certification issued on behalf of a corporation
Albright Services Group Pty Ltd, Trading as Albright Consulting Engineers</td><td colspan="2">Company NT Registration Number
215037ES</td></tr>
<tr><td colspan="4">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</td></tr>
<tr><td>Name
Nicholas Kastellorizios
Nominee for Albright Services Group Pty Ltd, Trading as Albright Consulting Engineers</td><td>Nominee/Individual NT Registration Number
215037ES</td><td>Signature</td><td>Date
11/12/2023</td></tr>
</table>

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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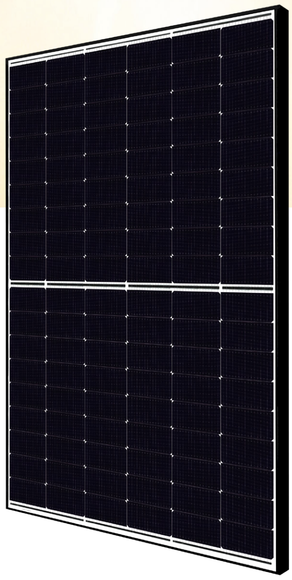
Appendix:

Data Sheet – Canadian Solar Panel Modules: 1722 mm x 1134 mm x 30 mm, 21.3 kg, TOPHiKu6 N-TYPE TOPCON: CS6R-420T; CS6R-425T; CS6R-430T; CS6R-435T & CS6R-440T

NEW

CanadianSolar



TOPHiKu6

N-type TOPCon Technology

420 W ~ 440 W

CS6R-420|425|430|435|440T (IEC1000 V)

CS6R-420|425|430|435|440T (IEC1500 V)

MORE POWER

440 W

Module power up to 440 W
Module efficiency up to 22.5 %

Excellent anti-LeTID & anti-PID performance.
Low power degradation, high energy yield

Lower temperature coefficient (Pmax): -0.29%/°C, increases energy yield in hot climate

Lower LCOE & system cost

MORE RELIABLE

Minimizes micro-crack impacts

Heavy snow load up to 5400 Pa, wind load up to 2400 Pa*

* For detailed information, please refer to the Installation Manual.

25 Years — **Industry Leading Product Warranty on Materials and Workmanship***

30 Years — **Linear Power Performance Warranty***

1st year power degradation no more than 1%
Subsequent annual power degradation no more than 0.4%

*Subject to the terms and conditions contained in the applicable Canadian Solar Limited Warranty Statement. Also this 25-year limited product warranty is available only for products installed and operating on residential rooftops in certain regions.

MANAGEMENT SYSTEM CERTIFICATES*

ISO 9001:2015 / Quality management system
ISO 14001:2015 / Standards for environmental management system
ISO 45001: 2018 / International standards for occupational health & safety
IEC62941: 2019 / Photovoltaic module manufacturing quality system

PRODUCT CERTIFICATES*

IEC 61215 / IEC 61730 / CE / INMETRO / MCS / UKCA
UL 61730 / IEC 61701 / IEC 62716 / IEC 60068-2-68
Take-e-way

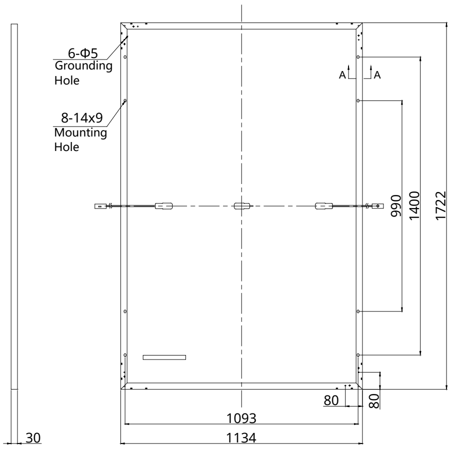
* The specific certificates applicable to different module types and markets will vary, and therefore not all of the certifications listed herein will simultaneously apply to the products you order or use. Please contact your local Canadian Solar sales representative to confirm the specific certificates available for your Product and applicable in the regions in which the products will be used.

CSI Solar Co., Ltd. is committed to providing high quality solar photovoltaic modules, solar energy and battery storage solutions to customers. The company was recognized as the No. 1 module supplier for quality and performance/price ratio in the IHS Module Customer Insight Survey. Over the past 22 years, it has successfully delivered around 100 GW of premium-quality solar modules across the world.

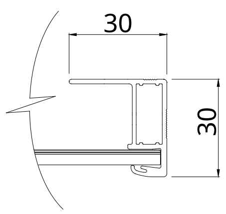
Canadian Solar MSS (Australia) Pty Ltd.
333 Drummond Street, Carlton VIC 3053, Australia, sales.au@csisolar.com, www.csisolar.com/au

ENGINEERING DRAWING (mm)

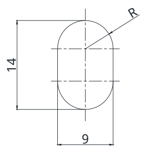
Rear View



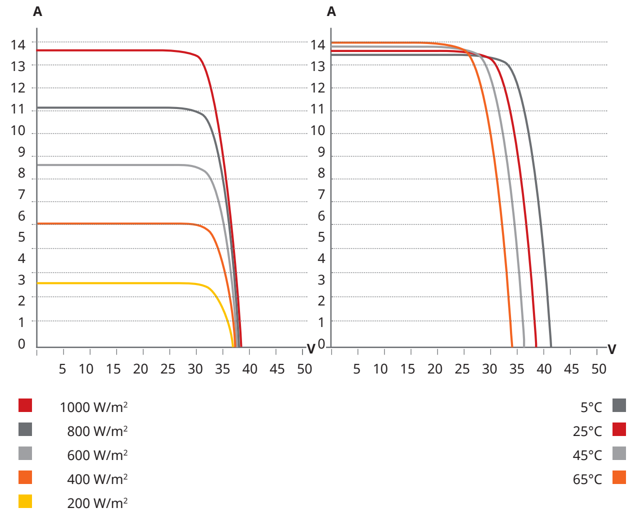
Frame Cross Section A-A



Mounting Hole



CS6R-420T / I-V CURVES



ELECTRICAL DATA | STC*

CS6R	420T	425T	430T	435T	440T
Nominal Max. Power (Pmax)	420 W	425 W	430 W	435 W	440 W
Opt. Operating Voltage (Vmp)	31.6 V	31.8 V	32.0 V	32.2 V	32.4 V
Opt. Operating Current (Imp)	13.30 A	13.37 A	13.44 A	13.51 A	13.59 A
Open Circuit Voltage (Voc)	38.6 V	38.8 V	39.0 V	39.2 V	39.4 V
Short Circuit Current (Isc)	13.71 A	13.78 A	13.86 A	13.94 A	14.01 A
Module Efficiency	21.5%	21.8%	22.0%	22.3%	22.5%
Operating Temperature	-40°C ~ +85°C				
Max. System Voltage	1500V (IEC/UL) or 1000V (IEC/UL)				
Module Fire Performance	TYPE 1 (UL 61730 1500V) or TYPE 2 (UL 61730 1000V) or CLASS C (IEC 61730)				
Max. Series Fuse Rating	25 A				
Application Classification	Class A				
Power Tolerance	± 5 W				

* Under Standard Test Conditions (STC) of irradiance of 1000 W/m², spectrum AM 1.5 and cell temperature of 25°C. Measurement uncertainty: ±3 % (Pmax).

ELECTRICAL DATA | NMOT*

CS6R	420T	425T	430T	435T	440T
Nominal Max. Power (Pmax)	318 W	321 W	325 W	329 W	333 W
Opt. Operating Voltage (Vmp)	29.9 V	30.1 V	30.3 V	30.4 V	30.6 V
Opt. Operating Current (Imp)	10.63 A	10.69 A	10.75 A	10.81 A	10.87 A
Open Circuit Voltage (Voc)	36.5 V	36.7 V	36.9 V	37.1 V	37.3 V
Short Circuit Current (Isc)	11.05 A	11.11 A	11.18 A	11.24 A	11.30 A

* Under Nominal Module Operating Temperature (NMOT), irradiance of 800 W/m², spectrum AM 1.5, ambient temperature 20°C, wind speed 1 m/s.

MECHANICAL DATA

Specification	Data
Cell Type	Mono-crystalline
Cell Arrangement	108 [2 X (9 X 6)]
Dimensions	1722 × 1134 × 30 mm (67.8 × 44.6 × 1.18 in)
Weight	21.3 kg (47.0 lbs)
Front Cover	3.2 mm tempered glass with anti-reflective coating
Frame	Anodized aluminium alloy,
J-Box	IP68, 3 bypass diodes
Cable	4 mm² (IEC), 12 AWG (UL)
Connector	Tlian: T6 Stäubli: PV-KST4/xy-UR, PV-KBT4/xy-UR or PV-KST4-EVO2/XY, PV KBT4-EVO2/XY or PV-KST4-EVO2A/XY, PV-KBT4-EVO2A/XY
Cable Length (Including Connector)	Portrait: 350 mm (13.8 in) (+) / 250 mm (9.8 in) (-); landscape: 1100 mm (43.3 in)*
Per Pallet	35 pieces
Per Container (40' HQ)	910 pieces

* For detailed information, please contact your local Canadian Solar sales and technical representatives.

TEMPERATURE CHARACTERISTICS

Specification	Data
Temperature Coefficient (Pmax)	-0.29 % / °C
Temperature Coefficient (Voc)	-0.25 % / °C
Temperature Coefficient (Isc)	0.05 % / °C
Nominal Module Operating Temperature	41 ± 3°C

PARTNER SECTION

* The specifications and key features contained in this datasheet may deviate slightly from our actual products due to the on-going innovation and product enhancement. CSI Solar Co., Ltd. reserves the right to make necessary adjustment to the information described herein at any time without further notice.
Please be kindly advised that PV modules should be handled and installed by qualified people who have professional skills and please carefully read the safety and installation instructions before using our PV modules.

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* Manufactured and assembled in China and Thailand.