



WESTERN FIRE CENTER, INC.

2204 Parrott Way, Kelso, Washington 98626
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Fire Testing of Photovoltaic Modules

*Indicative testing conducted in accordance with the test methodology
described in UL 1703*

Independent of Roof Covering – “Type”

Class A Spread of Flame, Class A Burning Brand

Slope: 5/12 (Unlimited)

Conducted For:

**RETC, LLC
46457 Landing Parkway
Fremont, CA 94538**

Manufacturer: GTC

Material Model: GTC-GG1H-295W

WFCi Report #15138

****The results of this report pertain only to the materials tested****

Test Date: November 30, 2015

Report Issued: April 4, 2016



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INTRODUCTION

Fire testing was performed to characterize the performance of modules independent of roof covering system or “Type” testing. A Class A spread of flame test and a Class A burning brand test (in accordance with the requirements of UL 1703) were conducted at a slope of 5 in per horizontal foot (5/12) on solar photovoltaic module specimens as received. Testing followed criteria established in Section 31 of the UL1703 standard, *Flat-Plate Photovoltaic Modules and Panels*.

31.1.2 Spread of flame on top surface

31.1.2.1 The spread-of-flame tests shall be conducted on PV modules or panels. Tests shall be conducted using the apparatus as described in the Standard Test Methods for Fire Tests of Roof Coverings, UL 790, and the tests modified as follows. Tests shall be conducted with the module or panel oriented such that the ignition flame is directed on the top surface of the module or panel with no roof covering below the module or panel.

31.1.2.2 At no time during the tests shall:

- a) Any portion of the module or panel be blown off or fall off the test deck in the form of flaming or glowing brands;
- b) The flame spread on the module or panel surfaces beyond 6 ft (1.82 m) in 10 minutes, 8 ft (2.4 m) in 10 minutes, or 13 ft (3.9 m) in 4 minutes depending upon the definition of the module or panel “Type” the test is being performed to verify in accordance with 16.4.1. The flame spread is to be measured from the leading edge of the test deck. Spread-of-flame includes flaming on both the top and bottom surface of the module or panel; or
- c) There be significant lateral spread-of-flame on the module or panel. Significant lateral spread shall be considered to have occurred when surface flaming beyond 1 foot (0.3 m) from the lead edge extends laterally on the module or panel to the full 40-inch (1016 mm) width of the test deck assembly. Lateral flame spread includes flame spread under or along the equipment under test.

With respect to (a), any piece of PV module or panel, that continues to glow or flame for 5 seconds or more upon landing on the test room floor is a glowing or flaming brand, respectively. A module or panel is not required to be usable after any of the tests of this Section.

31.1.3 Burning brand on top surface

31.1.3.1 Tests shall be conducted as described in the Standard Test Methods for Fire Tests of Roof Coverings, UL 790, and the tests modified as follows. Tests shall be conducted on the top surface of the module or panel with no roof covering below the module or panel using a specific type of brand (A, B, or C) as specified in the definition of the “Type” of module or panel the test is being performed to verify in accordance with 16.4.1.

31.1.3.2 At no time during the tests shall:

- a) Any portion of the module or panel be blown off or fall off the test deck in the form of flaming or glowing brands;
- b) The brand burn a hole through any part of the module or panel;
- c) There be sustained flaming of the module or panel Sustained flaming is considered any flaming which continues uninterrupted for 5 seconds or more.

With respect to (a), any piece of PV module or panel, that continues to glow or flame for 5 seconds or more upon landing on the test room floor is a glowing or flaming brand, respectively. A module or panel is not required to be usable after any of the tests of this Section.

Based off information from UL, these modules are to be placed over a non-combustible deck, though not specifically stated in the standard. The distance between the deck and the bottom of the panel was 5”.

TEST APPARATUS AND PROCEDURE

The essential elements of the UL 790 Fire Test Apparatus include a test deck mounted on an adjustable pitch steel frame, a gas burner or wood brand ignition source, a wind tunnel duct, and variable speed blowers to provide a controlled air flow across the test specimen. Airflow was measured at three locations across the test deck midway up the slope of the deck at its center and two outside edges. The measurements were made using an OMEGA-FLO™, Model No. HH-30, vane anemometer manufactured by Omega Engineering, Inc. The airflow is maintained at 12 ± 0.5 mph (5.4 ± 0.2 m/s) throughout the duration of the test.

For the **Class A Spread of Flame Test** a luminous gas flame is applied to the deck at a temperature of 1400 ± 50 °F (760 ± 28 °C) as measured by a type K 14 gauge thermocouple located 1 in above the surface and $\frac{1}{2}$ in toward the test flame from the lower edge of the first board of a noncombustible calibration deck. The flame covers approximately the width of the bottom portion of the deck and extends in a triangular pattern with flames extending upward a distance of $4\frac{1}{3}$ ft from the lower edge of the deck prior to any contribution (if any) from the deck. The flame is applied for 10 minutes for the Class A test. The flame attached to the deck is monitored for length of travel along the deck over the duration of the test.

For the **Class A Burning Brand Test**, the Class A brand was ignited on a gas burner for 5 minutes, and then placed on the module approximately 15" from the leading edge with the 12-mile per hour wind passing over it. The test continued until the brand was totally consumed and until all evidence of flaming, glowing, and smoke disappeared from both the exposed surface of the material being tested and the underside of the test deck or until failure occurred.

UL 1703 provides for single exposures to UL 790 spread of flame and burning brand test conditions. The testing in this project were conducted on self-supporting photovoltaic module panels. Calibration on the test apparatus was also performed on each day of testing.

SAMPLE DESCRIPTIONS

Modules (proposed "Type 13") were delivered to WFCi to perform fire testing to be "Type" tested for the fire tests. Module specifications are detailed in the Table 1 and Figure 1 below.

Table 1. Photovoltaic module specifications fire tests.

Manufacturer	GTC
Model Type	GTC-GG1H-295W (See APPENDIX A: MODEL CHANGE)
Serial Number	GG678804001650 (spread of flame – 1 st panel) GG678804001652 (spread of flame – 2 nd panel) GG678804001653 (burning brand)
Description of Materials	Unframed PV module sample, glass front, glass back
Dimensions	$65\frac{1}{2}" \times 39" \times \frac{3}{16}"$
Date Received	November 11, 2015



Figure 1. Photovoltaic module setup prior to burning brand test.

TEST RESULTS

The solar panels were tested as received by WFCi personnel to UL1703 test specifications. The Class A spread of flame and Class A burning brand “Type” tests were conducted with the test sample at a slope of 5/12. Flame or brands were positioned to be on the top surface of the solar modules. The test apparatus was calibrated in accordance with the standard. The spread of flame test and burning brand tests were performed on November 30, 2015.

Calibrations

The tables below show the calibrations and conditions of the test apparatus on the day of testing.

Table 2. Calibration of UL790 test apparatus. ‘±’ indicates standard deviation.

Calibration Date	November 30, 2015
Air Velocity	5.31 ± 0.07 m/s
Average flame temperature	762.0 ± 6.6°C
Gas flow rate (natural gas)	14.75 SCFM
Laboratory air temperature	18°C

Spread of Flame Test

Class A Spread of Flame: **Pass**

The test item complied with the conditions for Class A spread of flame. Observations from the tests are shown in Table 3 as well as images in Figure 2 below.

Table 3. Observations for spread of flame test.

Test Time (mm:ss)	Event
00:00	Start test – flame over modules
01:15	Bowing/warping of module
09:00	No significant changes
10:00	Terminate test – no ignition – PASSED

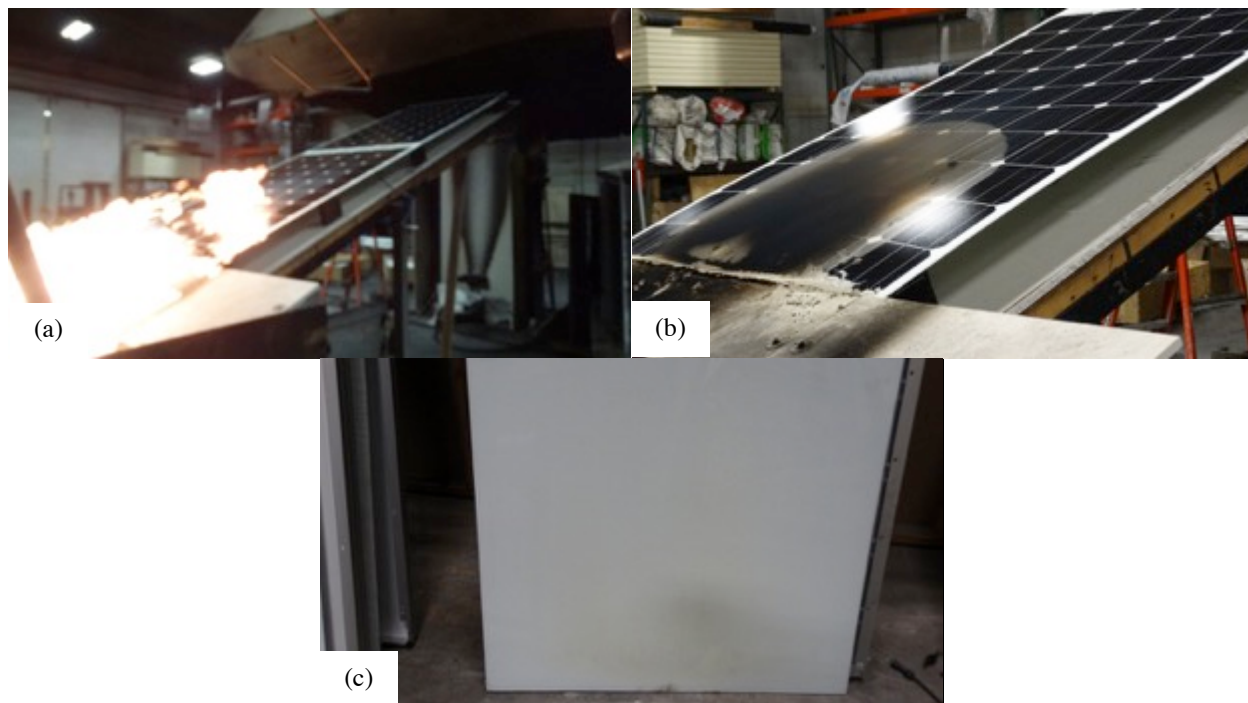


Figure 2. Spread of flame test showing (a) flames on module and (b-c) after test.

Burning Brand

Class A Burning Brand: **Pass**

The test item complied with the conditions for Class A burning brand. Observations from the tests are shown in Table 4 and images in Figure 3 below.

Table 4. Observations for burning brand test.

Test Time (mm:ss)	Event
00:00	Start test – place Class A brand on module
00:45	Bowing/warping of module
01:50	Top glass cracked
04:00	Brand approximately 40% consumed
08:45	Slight pop of module – brand approximately 85% consumed
09:30	Slight pop of module
13:15	Some glowing from brand remaining
16:10	All signs of combustion out – terminate test – PASSED

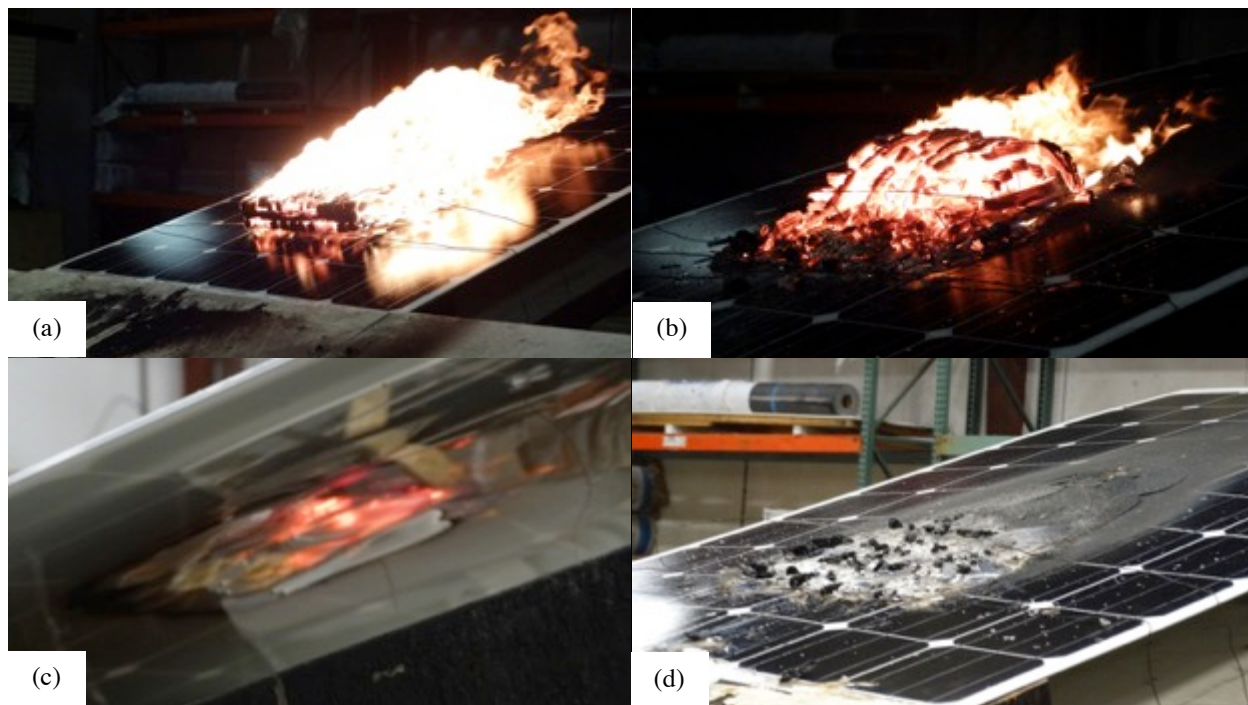


Figure 3. Burning brand test showing (a) applied brand, (b) partially consumed brand, (c) unexposed side, and (d) after test.

CONCLUSION

The sample panels submitted and tested as described above in this report successfully met the criteria for “Type 13” (Class A spread of flame, Class A burning brand) at the 5/12 slope in accordance with UL 1703. A summary of the testing results for each fire test is shown in Table 5 below.

Table 5. Summary of “Type” test results.

Model Type	Dimensions	Spread of Flame Passage	Burning Brand Passage
GTC-GG1H-295W	65½" × 39" × 3/16"	Class A - Yes	Class A - Yes

SIGNATURES

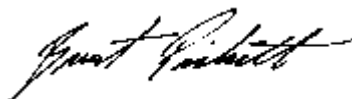
Testing performed by,

A handwritten signature in black ink, appearing to read "Mike White".

Mike White

Laboratory Manager

Reviewed and Approved by,

A handwritten signature in black ink, appearing to read "Brent M. Pickett".

Brent M. Pickett, Ph.D.

Technical Director

**WESTERN FIRE CENTER AUTHORIZES THE CLIENT NAMED HEREIN TO
REPRODUCE THIS REPORT ONLY IF REPRODUCED IN ITS ENTIRETY**

The test specimen identification is as provided by the client, and WFCi accepts no responsibility for any inaccuracies therein. WFCi did not select the specimen and has not verified the composition, manufacturing techniques, or quality assurance procedures.

APPENDIX A: MODEL CHANGE

GTC DIS TICARET LTD

Organize Sanayi 11 cadde No 2
Adiyaman , Turkiye 02040
Adiyaman VD 3130057834

08 03 2016

RETC, LLC

46457 Landing Parkway
Fremont, CA 94538

Dear Zennia Villanueva,

Please note the codes and labels of our 2 module types, the glass-glass and the glass-ceramic have been changed to reflect better their specifications based on the test results we have received so far
Please use the new codes and labels for your certification reports as per the below 2 sheets

Yours Sincerely,

Ayşe Ağdam
GİD. TEKSTİL ELEMAN
DIS TICARET LTD. STI.
Organize Sanayi Bölge 30. Ada 25. Parsel
ADYAMAN
Adiyaman VD 3130057834



PHOTOVOLTAIC MONO-CRYSTALLINE MODULE

MODULE TYPE: GTC-G3C1H-260W
MAXIMUM POWER(Pmax) : 260,624W
POWER TOLERANCE: %3
SHORT CIRCUIT CURRENT(Isc): 9,340 A
OPEN CIRCUIT VOLTAGE(Voc): 35,856 V
MAX POWER CURRENT(Ipm): 8,871 A
MAX POWER VOLTAGE(Vpm): 29,380 V
MAX SYSTEM VOLTAGE: 1500 V
FUSE RATING: 20 A
MODULE EFFICIENCY: 17,434 %
MODULE Dimension: 150x99.2 cm
MODULE Weight: 23 kg
SAFETY APPLICATION CLASS:A
SAFETY CLASS: II
FIRE SAFETY CLASS: A



All technical data above at standard test conditions.
AM 1.5, 1000 W/m² IRRADIANCE 25 °C CELL TEMPERATURE

WARNING ELECTRICAL HAZARD:

Solar modules produce high voltage when exposed to sunlight. Must be installed by electrical professionals. Cover modules when connecting wiring. Safety precautions described in module installation manual. Removal of terminal block or wrong installation voids warrant.

Barcode #: GC 678804001397

MADE IN TURKIYE

www.gtctrade.com



678804001397



PHOTOVOLTAIC MONO-CRYSTALLINE MODULE

MODULE TYPE: GTC-GG1H-295W
MAXIMUM POWER(Pmax) : 292,775W
POWER TOLERANCE: %3
SHORT CIRCUIT CURRENT(Isc): 9,327 A
OPEN CIRCUIT VOLTAGE(Voc): 39,940 V
MAX POWER CURRENT(Ipm): 8,841 A
MAX POWER VOLTAGE(Vpm): 33,117 V
MAX SYSTEM VOLTAGE: 1500 V
FUSE RATING: 20 A
MODULE EFFICIENCY: 17,705 %
MODULE Dimension: 166.7x99.2 cm
MODULE Weight: 19.8 kg
SAFETY APPLICATION CLASS:A
SAFETY CLASS: II
FIRE SAFETY CLASS: A



All technical data above at standard test conditions.
AM 1.5, 1000 W/m² IRRADIANCE 25 °C CELL TEMPERATURE

WARNING ELECTRICAL HAZARD:

Solar modules produce high voltage when exposed to sunlight. Must be installed by electrical professionals. Cover modules when connecting wiring. Safety precautions described in module installation manual. Removal of terminal block or wrong installation voids warrant.

Barcode #: GG 678804001661

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