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Testing. Advising. Assuring.

Solar Collector Test Report

A Report to:	**Jiangsu Sunrain Solar Energy Co., Ltd.** Ninghai Industrial Zone Lianyungang, Jiangsu China
Attention:	**Neil Xi**
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Report No.:	09-08-0138-3 5 Pages, 2 Appendices
Proposal No.	09-008-1513RV1
Date:	June 8, 2010

1.0 INTRODUCTION

This report documents testing performed by Exova of the second of three evacuated tube liquid heating solar collectors for **Jiangsu Sunrain Solar Energy Co., Ltd.**

Testing was done in accordance with CAN/CSA-F378-87 Standard *"Solar Collectors"*. The following tests were done at the National Solar Test Facility:

- Initial Inspection
- 6.2.1 Initial Static Pressure Test
- 6.2.3 Outdoor No Flow Exposure Test
- 6.2.4 Thermal Performance Tests, including:
  - Collector Time Constant
  - Collector Efficiency
  - Incident Angle Modifier Test
- 6.2.1 Second Static Pressure Test
- 5.10 Final Inspection

The National Solar Test Facility is operated by Exova for Natural Resources Canada.

2.0 SAMPLE DESCRIPTION

Exova Sample No.:	09-08-0138-3
Manufacturer Name:	Jiangsu Sunrain Solar Energy Co., Ltd.
Collector Model:	TZ58/1800-R1
Serial Number:	N/A
Collector Type:	Evacuated tube, liquid-heating
Collector Enclosure:	Extruded aluminum frame, bottom rail and header box
Connections:	1" NPT male brass pipe
Glazing:	Borosilicate glass vacuum tubes (30)
Absorber Material:	Coated glass tubes, copper heat pipes, aluminum fins
Absorber Coating:	Dark blue selective coating (CERMET) on inner evacuated tubes
Insulation:	Compressed fibreglas layer (1/2" thick) around manifold, then header box is filled with rigid foam insulation
Gross Dimensions:	
Header Box:	203.0 mm length; 2418.0 width; area: 0.491 m²
Frame:	1767.0 mm length; 2369.0 mm width; area: 4.186 m²
Total Gross Area:	4.677 m²
Aperture Dimensions:	
Tubes:	1715.0 mm length x 1740.0 mm width (30 tubes x 58.0 mm O.D.)
Aperture Area:	2.9841 m²
Mounting Details:	Attached to test frame with Unistrut
Heat Transfer Fluid:	50/50% by vol. propylene glycol/water

Comments:

1. Average wind speed during testing was measured with a calibrated TSI Velocicalc anemometer (MII# B12230);
2. Thermal performance testing was done at the CSA standard F378 recommended flow rate of 0.02 L/s/m^2 (0.094 kg/s);
3. Inlet and outlet connections were insulated and therefore not included in the gross area.

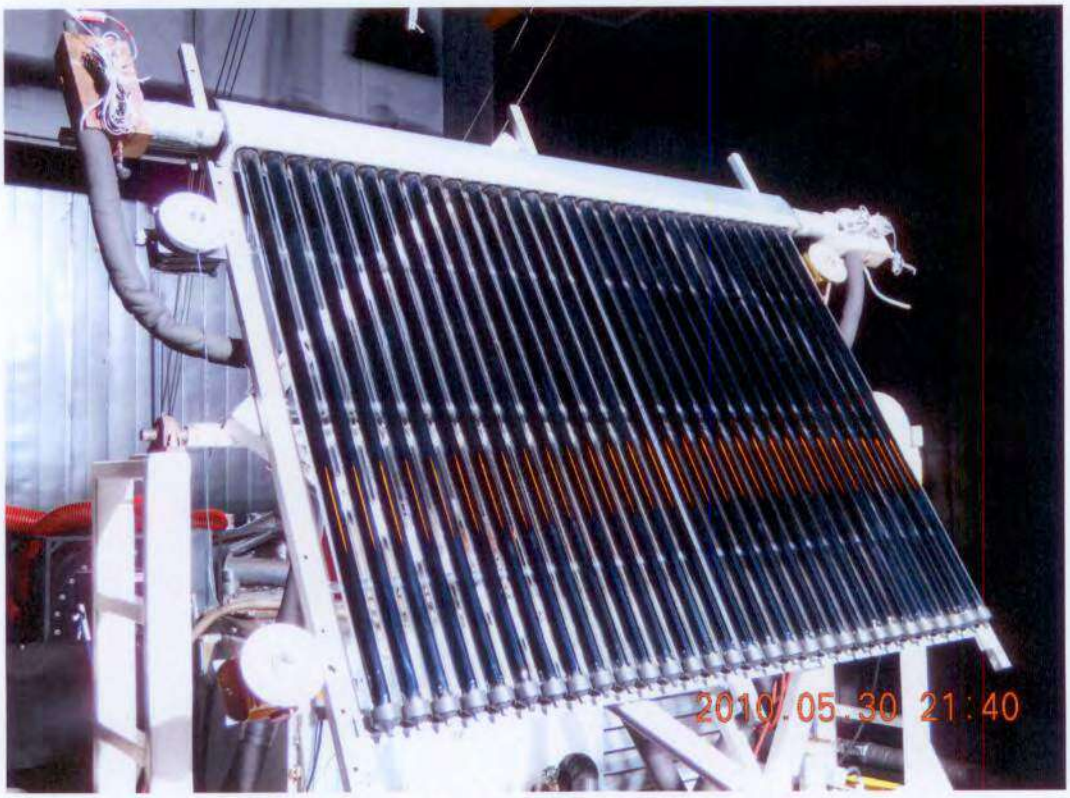


Figure 1: Jiangsu Sunrain Solar Energy model TZ58/1800-R1 collector under test.

3.0 STATIC PRESSURE TEST

CAN/CSA standard F378-87 requires that solar collector static pressure leakage tests are performed before and after the outdoor exposure test. The purpose of the static pressure leakage test is to ensure the integrity of solar collectors under conditions of hydraulic pressure at constant temperature. Test results are included in Appendix B.

4.0 EXPOSURE TEST

CAN/CSA standard F378-87 requires that solar collectors undergo an outdoor no-flow exposure test. This test includes a preconditioning rain penetration test, 30 days exposure (not necessarily consecutive) with a minimum of 17 MJ of incident energy per square meter of collector surface area, and a cold fill test.

Outdoor exposure testing was performed as specified in Section 6.2.3 of CAN / CSA standard F378-87. A written description of changes observed during the test is given in Appendix B. Insolation and ambient temperature data are recorded at five minute intervals for the duration of the exposure period. The cold fill test was done using 50/50% by vol. propylene glycol/water as the heat transfer fluid. Test results are included in Appendix B.

The dates of the days on which the total incident energy in the plane of the collector exceeded 17 MJ/m² are also recorded. The collector described in this report was exposed from September 8, 2009 to November 23, 2009. The 90-minute exposure requirement described in Section 6.2.3.4(f) of the standard was met on September 19, 2009 between 12:25 PM and 1:55 PM.

5.0 TIME CONSTANT

Before a collector may be properly tested, its time constant must be known in order to determine stabilization and data integration periods.

The time constant for this collector was determined in the solar simulator, and in accordance with section 6.2.4 of CAN / CSA standard F378-87. Simulated solar radiation was applied at 900 W/m². The solar simulator was turned off when the collector inlet temperature stabilized near ambient temperature. The change in temperature rise across the collector was then recorded as a function of time. CAN / CSA standard F378-87 defines the time constant as the time until the temperature difference between the inlet and the outlet of the collector is less than one-third of its value before the collector was covered. The time constant for the collector described in this report was 16 minutes and 55 seconds, at a flow rate of 0.093 kg/s. The average collector fluid inlet temperature was 25.0 °C during the time constant test, with an average ambient air temperature of 24.8 °C.

6.0 THERMAL EFFICIENCY

The test sample was mounted to liquid collector test frame #2 (MII # A06252). Insulated inlet and outlet connections that incorporate fluid temperature sensors were attached. In this way the collector becomes part of a circulation system that is provided with accurate temperature measurement at inlet and outlet.

The mass flow rate times specific heat product ($m \bullet c_p$) is measured directly using a calorimetric method for thermal performance testing. This product, expressed in units of W/°C, is determined by measuring the fluid temperature rise for a given electrical power input in an insulated container. The value of this product is not significantly changed as the fluid passes through the collector, therefore the product of $m \bullet c_p$ and collector temperature rise (ΔT) is the rate at which energy is collected. Values obtained in this way were used to calculate the efficiency of the collector described in this report.

Thermal efficiency testing was determined in the solar simulator, and in accordance with CAN/CSA standard F378-87 and referenced standard ANSI/ASHRAE 93-2003 (Section 8.3.3). The plane of the collector was tilted 60 degrees from horizontal, and was maintained normal to the direction of irradiation during testing. Testing was performed at a flow rate of 0.093 kg/s, at a measured average wind speed of 2.8 m/s.

Thermal efficiency test data accompanied by appropriate graphs are included in Appendix A. Collector efficiency was calculated using selected average data acquired by the frame computer. The following curve fits in SI units were derived from the averaged test frame data:

Based on collector gross area of 4.677 m^2:

1st order fit: Efficiency = 0.417 - 1.337(Ti-Ta)/G
2nd order fit: Efficiency = 0.415 - 1.030(Ti-Ta)/G - 0.0051(Ti-Ta)²/G

Based on collector aperture area of 2.984 m^2:

1st order fit: Efficiency = 0.654 - 2.095(Ti-Ta)/G
2nd order fit: Efficiency = 0.651 - 1.614(Ti-Ta)/G - 0.0080(Ti-Ta)²/G

where: Ti = collector inlet temperature, °C
Ta = ambient air temperature, °C
G = total irradiance on plane of collector, Watts/m^2

7.0 INCIDENT ANGLE MODIFIER (IAM) TEST

The IAM is a measure of the deviation of the collector thermal performance from cosine response. Horizontal and vertical IAM testing was done using the solar simulator, and in accordance with CAN/CSA Standard F378-87 and referenced Standard ANSI/ASHRAE 93-2003 (Section 8.3.4).

During the IAM test the collector was set successively at 0°, 30°, 45°, and 60° angles from normal incidence, while the solar simulator lamp beam was tilted 15 degrees down from horizontal. In this way, when measuring the vertical IAM the collector tubes (and the heat pipes) were at a 15° slope from horizontal for the 60° incident angle tests.

Collector inlet temperature was set equal to ambient temperature, and the thermal efficiency was determined at the various angles of incidence. Since the solar collector and its associated pyranometer were tracked off axis, the value of incident solar radiation reported is actually the solar radiation in the plane of the collector. Thermal efficiency relative to that at normal incidence was plotted against incident angle. The plots and average data are included in Appendix A.

8.0 FINAL INSPECTION

The purpose of this test is to determine the extent of any damage or degradation of the collector that occurred as a result of the previous test sequence. The collector was fully disassembled for this inspection. Final inspection results and photos are included in Appendix B.

Reported by:

Larry West, CET
Senior Technologist - Solar,
National Solar Test Facility

Reviewed by:

Alfred Brunger, P.Eng, Ph.D
Technical Manager, Energy Systems
National Solar Test Facility

This report refers only to the particular samples, units, material, instrument, or other subject used and referred to in it, and is limited by the tests and/or analyses performed. Similar articles may not be of like quality, and other testing and/or analysis programs might be desirable and might give different results.

APPENDIX A

(4 Pages)

Detailed Efficiency Data Legend

Thermal Efficiency

Incident Angle Modifier

DETAILED EFFICIENCY DATA

The following data contain calculated values of efficiency together with associated variables as follows:

Time :	Eastern Standard Time
Len :	Integration period (minutes)
G :	Total insolation on plane of collector (W/m²)
Gdn :	Direct beam solar radiation as measured by the normal incidence pyrheliometer (W/m²)
Ta :	Ambient air temperature (°C)
Ti :	Inlet fluid temperature (°C)
ΔT :	Temperature rise across collector (°C)
$\dot{m}$:	Mass flow rate (kg/s)
Ws :	Wind speed (m/s)
Wd :	Wind direction (degrees from North)
Output :	Net power delivered by collector (W/m²)
η :	Collector efficiency
ΔP:	Pressure drop across the collector (kPa)
K :	Incident angle modifier
θ :	Incident angle between solar radiation and collector normal

Apparent Solar Time = Time - 18.64 min + Equation of time

Thermal Efficiency Test Data

Jiangsu Sunrain Solar Energy Co., Ltd.

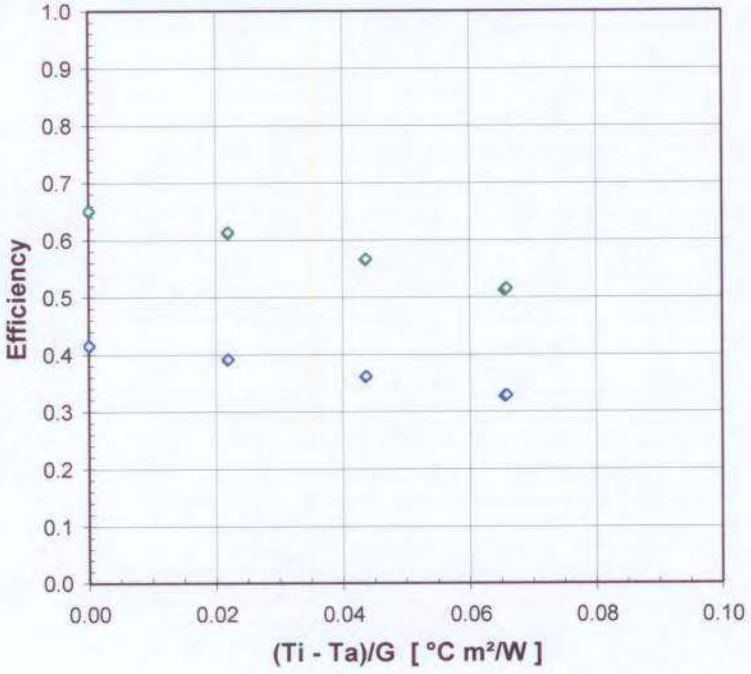
Date/Time	Len	G	Gdn	Ta	Ti	ΔT	Ws	ṁ•Cp	ṁ*	Ti-Ta	(Ti-Ta)/G	η	ΔP
	min.	*W/m²*	*W/m²*	*°C*	*°C*	*°C*	*m/s*	*W/°C*	*kg/s*	*°C*	*°C m²/ W*		*kPa*
2010-05-30 21:31	5	907	n/a	25.0	25.0	5.29	2.8	333.0	0.0932	0.0	0.0000	0.415	10.1
2010-05-30 21:36	5	908		25.0	25.0	5.29	2.8	333.1	0.0932	0.0	0.0001	0.414	
2010-05-30 21:41	5	908		25.0	25.0	5.29	2.8	332.9	0.0932	0.0	0.0000	0.415	
2010-05-30 21:46	5	908		25.0	25.0	5.29	2.8	333.1	0.0932	0.0	0.0000	0.415	
2010-05-31 8:52	5	912		25.0	45.0	4.94	2.8	337.8	0.0926	20.0	0.0219	0.391	n/a
2010-05-31 8:58	5	915		25.0	45.0	4.94	2.8	338.1	0.0927	20.0	0.0219	0.390	
2010-05-31 9:03	5	914		25.0	45.0	4.94	2.8	337.7	0.0926	20.0	0.0219	0.390	
2010-05-31 9:08	5	912		25.0	45.0	4.94	2.8	337.9	0.0927	20.0	0.0220	0.391	
2010-05-31 10:52	5	918		25.0	65.0	4.47	2.8	345.5	0.0929	40.0	0.0436	0.360	n/a
2010-05-31 10:57	5	916		25.0	65.0	4.48	2.8	345.2	0.0928	40.0	0.0436	0.361	
2010-05-31 11:02	5	915		25.0	65.0	4.48	2.8	345.3	0.0928	40.0	0.0437	0.361	
2010-05-31 11:07	5	915		25.0	65.0	4.47	2.8	345.4	0.0928	40.0	0.0437	0.361	
2010-05-31 12:45	5	915		25.1	85.0	3.96	2.8	352.9	0.0930	59.9	0.0655	0.327	n/a
2010-05-31 12:50	5	912		25.1	85.0	3.96	2.8	353.5	0.0932	59.9	0.0657	0.328	
2010-05-31 12:55	5	912		25.1	85.0	3.96	2.8	352.8	0.0930	59.9	0.0657	0.327	
2010-05-31 13:00	5	910		25.1	85.0	3.96	2.8	353.1	0.0931	59.9	0.0658	0.328	

* mass flow rate is calculated from measured values of m•Cp.

Indoor Simulator Test
Direct Radiation Only

Exova Sample No.:	09-08-0138-3
Collector Model:	TZ58/1800-R1
Test Date(s):	2010-May-30
Test Fluid:	50/50 propylene glycol/water
Mass Flow Rate:	0.093 *kg/s*
Wind Speed (average):	2.8 *m/s*
Gross Area:	4.677 *m²*
Aperture Area:	2.984 *m²*
Mean Ambient Temp.:	25.0 *°C*
Irradiance Intensity:	912 *W/m²*

Curve Fits:
1st Order (SI units):
Eff = 0.417 - 1.337(Ti-Ta)/G
2nd Order (SI units):
Eff = 0.415 - 1.030(Ti-Ta)/G - 0.0051(Ti-Ta)²/G



Horizontal Incident Angle Modifier Test Data

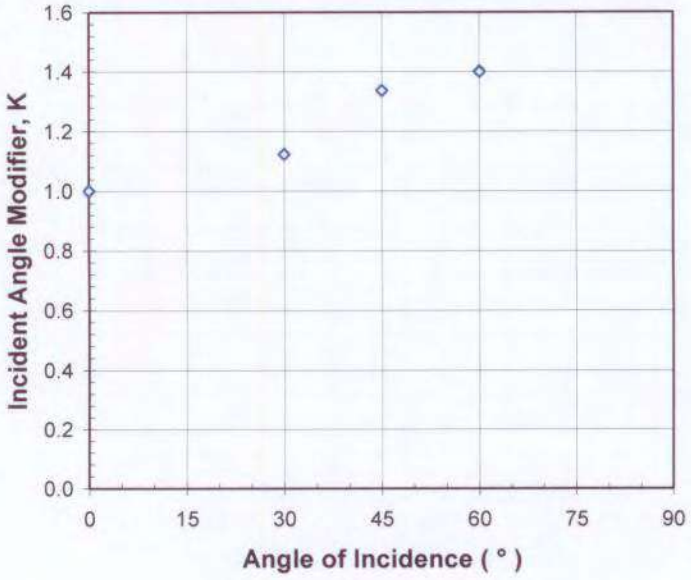
Jiangsu Sunrain Solar Energy Co., Ltd.

Date/Time	Len *min.*	G *W/m²*	Gdn *W/m²*	Ta *°C*	Ti *°C*	ΔT *°C*	ṁ•Cp *(W/°C)*	ṁ * *kg/s*	Ti-Ta *°C*	(Ti-Ta)/G *°C m²/ W*	η	K
θ = 0°												
2010-05-31 16:10	5	902	n/a	25.0	25.0	5.31	331.5	0.093	0.0	-0.00003	0.417	1.000
2010-05-31 16:15	5	902		25.0	25.0	5.31	331.5	0.093	0.0	-0.00001	0.417	1.001
2010-05-31 16:20	5	903		25.0	25.0	5.31	331.4	0.093	0.0	-0.00003	0.417	0.999
2010-05-31 16:25	5	902		25.0	25.0	5.31	331.4	0.093	0.0	-0.00003	0.417	1.000
θ = 30°												
2010-05-31 17:15	5	813		25.0	25.0	5.36	331.8	0.093	0.0	-0.00001	0.468	1.122
2010-05-31 17:20	5	813		25.0	25.0	5.36	331.8	0.093	0.0	0.00003	0.468	1.122
2010-05-31 17:25	5	812		25.0	25.0	5.36	331.8	0.093	0.0	-0.00001	0.468	1.123
2010-05-31 17:30	5	811		25.0	25.0	5.35	331.8	0.093	0.0	0.00001	0.468	1.122
θ = 45°												
2010-05-31 19:05	5	679		25.0	25.0	5.33	331.7	0.093	0.0	0.00004	0.557	1.337
2010-05-31 19:10	5	678		25.0	25.0	5.33	331.7	0.093	0.0	0.00003	0.557	1.337
2010-05-31 19:15	5	678		25.0	25.0	5.32	331.7	0.093	0.0	0.00005	0.557	1.336
2010-05-31 19:20	5	678		25.0	25.0	5.32	331.7	0.093	0.0	0.00003	0.557	1.336
θ = 60°												
2010-05-31 20:59	5	471		25.0	25.0	3.87	332.6	0.093	0.0	-0.00003	0.584	1.401
2010-05-31 21:09	5	471		25.0	25.0	3.87	332.6	0.093	0.0	-0.00005	0.584	1.401
2010-05-31 21:14	5	471		25.0	25.0	3.87	332.5	0.093	0.0	-0.00002	0.584	1.401
2010-05-31 21:19	5	472		25.0	25.0	3.87	332.6	0.093	0.0	0.00001	0.583	1.398

* mass flow rate is calculated from measured values of m•Cp.

Exova Sample No.:	09-08-0138-3
Collector Model:	TZ58/1800-R1
Test Date:	2010-May-31
Test Fluid:	50/50 propylene glycol/water
Mass Flow Rate:	0.093 *kg/s*
Wind Speed (nominal):	2.8 *m/s*
Mean Ambient Temp.:	25.0 *°C*
Gross Area:	4.677 *m²*
Aperture Area:	2.984 *m²*

Indoor Simulator Test
Direct Radiation Only



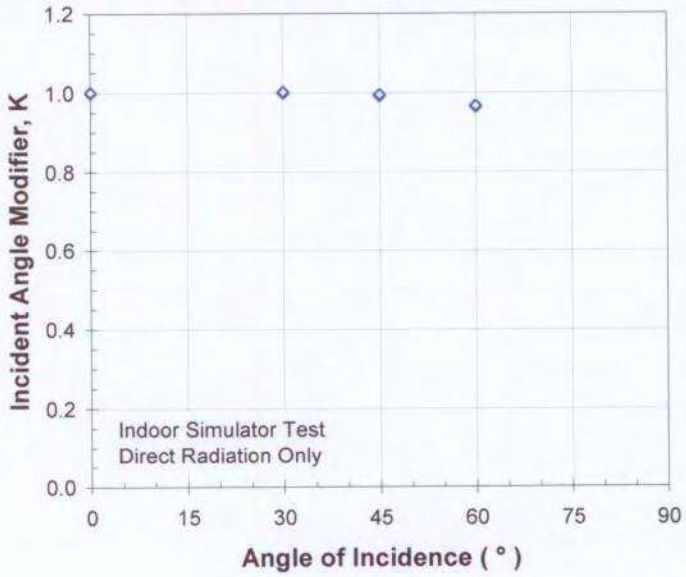
Vertical Incident Angle Modifier Test Data

Jiangsu Sunrain Solar Energy Co., Ltd.

Date/Time	Len *min.*	G *W/m²*	Gdn *W/m²*	Ta *°C*	Ti *°C*	ΔT *°C*	ṁ•Cp *(W/°C)*	ṁ * *kg/s*	Ti-Ta *°C*	(Ti-Ta)/G *°C m²/W*	η	K
θ = 0°												
2010-05-31 23:14	5	902	n/a	25.0	25.0	5.32	331.7	0.093	0.1	0.00006	0.419	1.001
2010-05-31 23:24	5	903		25.0	25.0	5.33	331.7	0.093	0.0	0.00005	0.418	1.000
2010-05-31 23:29	5	904		24.9	25.0	5.32	331.8	0.093	0.1	0.00007	0.418	0.999
2010-05-31 23:35	5	903		24.9	25.0	5.32	331.8	0.093	0.1	0.00008	0.418	1.001
θ = 30°												
2010-06-01 8:16	5	781		25.0	25.0	4.61	331.7	0.093	0.0	0.00002	0.418	1.000
2010-06-01 8:21	5	782		25.0	25.0	4.61	331.8	0.093	0.0	0.00002	0.418	0.999
2010-06-01 8:26	5	783		25.0	25.0	4.61	331.6	0.093	0.0	0.00005	0.418	0.998
2010-06-01 8:42	5	781		25.0	25.0	4.61	331.6	0.093	0.0	0.00004	0.418	1.000
θ = 45°												
2010-06-01 10:14	5	637		24.9	25.0	3.72	332.3	0.093	0.1	0.00023	0.415	0.993
2010-06-01 10:19	5	637		24.9	25.0	3.72	332.2	0.093	0.2	0.00024	0.415	0.992
2010-06-01 10:24	5	638		24.9	25.0	3.72	332.2	0.093	0.2	0.00024	0.414	0.991
2010-06-01 10:29	5	637		24.8	25.0	3.72	332.3	0.093	0.2	0.00027	0.415	0.994
θ = 60°												
2010-06-01 12:00	5	440		25.1	25.0	2.50	332.6	0.093	-0.1	-0.00013	0.403	0.963
2010-06-01 12:06	5	440		25.1	25.0	2.50	332.5	0.093	-0.1	-0.00015	0.403	0.963
2010-06-01 12:11	5	440		25.1	25.0	2.50	332.6	0.093	-0.1	-0.00014	0.404	0.965
2010-06-01 12:16	5	439		25.1	25.0	2.49	332.6	0.094	-0.1	-0.00014	0.404	0.965

* mass flow rate is calculated from measured values of m•Cp.

Exova Sample No.:	09-08-0138-3
Collector Model:	TZ58/1800-R1
Test Dates:	2010-May-31
Test Fluid:	50/50 propylene glycol/water
Mass Flow Rate:	0.093 *kg/s*
Wind Speed (nominal):	2.8 *m/s*
Mean Ambient Temp.:	25.0 *°C*
Gross Area:	4.677 *m²*
Aperture Area:	2.984 *m²*



APPENDIX B
(11 pages)

Liquid Collector Static Pressure Leakage

Rain Penetration

Exposure Days

Outdoor No Flow Exposure

Cold Fill

Liquid Collector Static Pressure Leakage

Pressure Drop

Final Inspection

Final Inspection Photos

Liquid Collector Static Pressure Leakage Test

(CSA standard F378-87, section 6.2.1)

GENERAL

EXOVA Sample No.: 09-08-0138-3
Manufacturer: Jiangsu Sunrain Solar Energy
Model No.: TZ58/1800-R1
Recommended Fluid: 50/50 glycol/water
Fluid Temperature (ambient air temperature ±3 °C): 21 °C
Tested by: JUAN CHINCHILLA Date: 2009/08/28

TEST PRESSURE

Manufacturers' Recommended Working Pressure (RWP): 600 / 87 kPa / psi
Test Pressure (1.5 times RWP): 900 / 131 kPa / psi

PRESSURE TEST

ITEM		TIME	PRESSURE (kPa / psi)
A	Before pressure applied	7:17	0
B	Immediately after pressure applied	"	130
C	15 minutes after pressure applied	7:32	133
D	Immediately after pressure released	"	0

ΔP = Pressure B - Pressure C = -3 kPa / psi

Equipment used: Pressure gauge MII# B01323
Thermometer MII# B07574

RESULTS

Collector Accepted (dP = 0) [✓]
Rejected (dP > 0) [ ]

Approved by: Larry E Wert Date: 2010-06-08

Outdoor No Flow Exposure Test

(CSA standard F378-87, section 6.2.3)

BODYCOTE sample no.: 09-08-0138-3
Manufacturer: Jiangsu Sunrain Solar
Model no.: TZ58/1800-RI series
Exposure start date: 2009/09/08 (9:45) Signature: J Churchill

INSPECTIONS (WEEKLY)

DATE	INITIALS	OBSERVATIONS OF CHANGES
2009-09-14	RR	No change
2009-09-21	JC	" "
2009-09-28	RR	" "
2009-10-05	JC	" "
2009-10-13	JC	" "
2009-10-19	JC	" "
2009-10-26	RR	" "
2009-11-02	JC	" "
2009-11-09	RR	" "
~~2009-11-09R~~	~~RRP~~	
2009-11-16	JC	" "
2009-11-23	JC	" "
2009-11-23	JC	Pumped @ 15:00

Exposure period in which insolation rate (I) = 950 + 5(30 - $T_{ambient}$) W/m² for 90 minutes after collector has boiled dry (wind speed <5 m/s during period):

Date: 2009-9-19 Time: 12:25 PM to 1:55 PM

Exposure termination date: 2009-11-23
Reason: [x] exposure completed
[ ] structural damage

Approved by: Gary Elliott Date: 2010-06-06

Outdoor No Flow Exposure Test, Exposure Days

Month	Exposure Days - 2009	Totals
January	3,5,15,16,20,24,26,27	8
February	1,2,5,6,8,9,13,15,16,23,24,25,26,28	14
March	1,2,3,4,12,13,14,15,16,17,19,20,21,22,23,24,27,28	17
April	2,5,8,9,10,11,12,13,15,16,17,19,23,24,25,29	15
May	1,2,3,4,5,6,7,8,10,11,12,13,14,15,17,18,19,20,21,22,23,24,25,29,30,31	26
June	2,3,4,5,6,7,9,10,12,13,14,15,16,19,21,22,23,24,25,26,27	21
July	1,2,3,4,5,6,9,10,11,12,13,14,15,16,18,19,20,24,27,30,31	21
August	1,2,3,5,6,7,9,10,11,12,13,14,15,16,17,18,19,21,24,25,26,27,29,31	24
September	1,2,3,4,5,6,7,8,9,10,12,13,14,15,16,17,18,19,20	19
October	5,8,10,11,13,14,16,17,18,19,25	11
November	6,7,8,12,13,14,17,18	8
December	6,12,22	3

NOTE: An exposure day is one on which the total recorded solar energy incident on the plane of the collector is at least 17 MJ/m².

Outdoor Exposure Tests:

Client	Standard	Start Date	End Date	Sample no.	Exposure Days
Jiangsu Sunrain Solar Energy Co.	CSA F378	2009-Sep-08	2009-Nov-24	09-08-0138-3	31

Rain Penetration Test

(CSA standard F378-87, section 6.2.3.4)

BODYCOTE Sample No.: 09-08-0138-~~4~~ 3
Manufacturer: Jiangsu Sunrain Solar Energy
Model No.: TZ58/1800-R1 series
Recommended Working Fluid: Water
Tested by: J Churchilla Date: 2009/09/10

Test start time: 7:50 Test Duration: 30 minutes
Flow Rate: >0.06 L/s per horizontal m²
Test Completion Time: 8:20

Visible signs of leakage: YES (NO)

Description of leakage (if any):

Comments:

NOTE: There are no acceptance criteria relating to degree of rain penetration.

Approved by: Tony E West Date: 2010-06-08

Cold Fill Test

(CSA standard F378-87, section 6.2.3.4)

GENERAL

BODYCOTE Sample No.: 09-08-0138-3
Manufacturer: Jiangsu Sunrain Solar
Model No.: T258/1800-RI Series
Fill Rate (0.02 kg/s/m² of collector area): 0.0206 L/s
Ambient Air Temperature: 15 °C
Fluid Temperature (ambient temp. ±5°C): 19 °C
Tested by: [signature] Date: 2010-04-14

Start time for Insolation Period (min. period 1 hour at 900 W/m²): 11:44
Earliest test time: 12:44

Test start time: 12:46 Test Duration: 5 minutes
Test completion time: 12:51

INSPECTION

Visible signs of damage: YES (NO)

Description of damage (if any):

Equipment used: Thermometer MII#: B07574

Approved by: Tony Ewert Date: 2010-06-06

Liquid Collector Static Pressure Leakage Test

(CSA standard F378-87, section 6.2.1)

GENERAL

BODYCOTE Sample No.: 09-08-0138-3
Manufacturer: Jiangsu Sunrain Solar Energy
Model No.: TZ58/1800
Recommended Fluid: 50/50 Glycol/Water
Fluid Temperature (ambient air temperature ±3 °C): 26 °C
Tested by: [signature] Date: 2010-05-30

TEST PRESSURE

Manufacturers' Recommended Working Pressure (RWP): 600 (kPa) / psi 87 psi
Test Pressure (1.5 times RWP): 900 (kPa) / psi 131 psi

PRESSURE TEST

	ITEM	TIME	PRESSURE (kPa / psi)
A	Before pressure applied	7:32	0 psi
B	Immediately after pressure applied	7:33	131 psi
C	15 minutes after pressure applied	7:48	131 psi
D	Immediately after pressure released	7:48	0 psi

ΔP = Pressure B - Pressure C = 0 kPa / psi

Equipment used: Pressure gauge MII# B01323
Thermometer MII# B07574

RESULTS

Collector Accepted (dP = 0) [✓]
Rejected (dP > 0) [ ]

Approved by: Larry E West Date: 2010-06-06

Collector Pressure Drop Test Results

Standard: **ISO 9806-1, section 12**
Test Date: 2010-Jun-01

Gross Area = **4.677** m²
Tested using U-tube manometer MII# B02046

Comments	Flow Rate (kg/s per m²)	Desired Flow (kg/s)	Actual Flow (kg/s)	Actual Flow (W/°C)	T_in (°C)	T_amb (°C)	Measured P_drop (mmH_2O)	P_drop (Pa)
	0	0.0000	0	0.0	25.0	25.0	0	0
	0.005	0.0234	0.0234	83.0	24.9	25.0	102	1052
	0.010	0.0468	0.0466	165.4	25.0	24.9	296	3053
	0.015	0.0702	0.0700	248.7	25.0	24.6	592	6106
standard	0.020	0.0935	0.0934	331.9	25.0	25.1	978	10087
	0.025	0.1169	0.1169	415.2	25.0	25.7	1453	14987

HTF = 50/50 propylene glycol/water
D0 = 1.052 kg/L