

Solar Collector Test Report

A Report to: **Backwards to the Future Ltd.**
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Fennville, MI
USA 49408

Attention: **Mr. Richard Oraweic**
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Report No.: 04-08-0529
7 Pages plus 2 Appendices

Date: December 24, 2004

1.0 INTRODUCTION

This report documents testing of an evacuated tube liquid solar collector **Backwards to the Future Ltd.** The full series of solar collector tests was conducted at the National Solar Test Facility (NSTF). Testing was conducted in accordance with **SRCC Standard 100** “*Test Methods and Minimum Standards for Certifying Solar Collectors*”.

The National Solar Test Facility is operated by Bodycote Materials Testing Canada Inc. for Natural Resources Canada.

2.0 SAMPLE DESCRIPTION

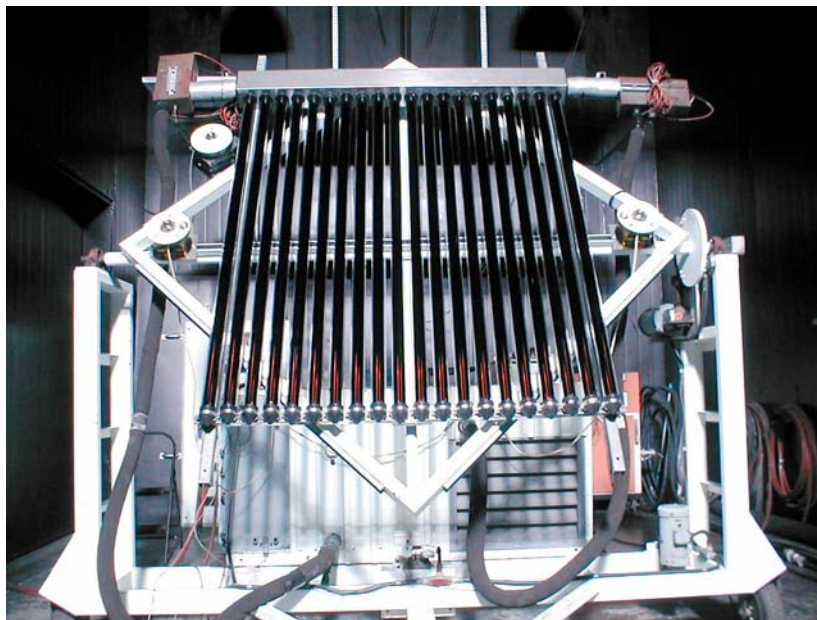


Figure 1: Photo of test sample 04-08-0529 in under test in the solar simulator chamber.

Bodycote sample number:	04-08-0529
Manufacturer name:	Backwards to the Future Ltd.
Collector model:	SP-20
FSEC identification:	00144
Serial number:	n/a
Collector type:	Liquid
General construction:	Evacuated tubes (20) inserted into insulated header manifold
Connections:	$\frac{3}{4}$ ” unions on copper pipes
Cover plate:	n/a
Absorber material(s):	Glass, aluminum spacers, copper heat pipes
Absorber coating:	black inner surface of inner glass tube
Gross dimensions:	Area: 3.075 m ² (includes header box)

Aperture dimensions:	Area: 2.01 m ² (20 tubes x 1.73 m x 0.058 m) (Based on O.D. of outer glass tubes)
Absorber area:	1.56 m ² (20 tubes x 1.73 m x 0.045 m) (Estimated cross-sectional area of exposed black inner tubes)
Heat transfer fluid:	Water

3.0 STATIC PRESSURE TEST

Section 4.2 of SRCC Standard 100 requires that static pressure leakage tests be performed before and after outdoor exposure testing. The static pressure leakage test consists of hydraulically or pneumatically testing all collectors for leaks. The applied test pressure and test results are reported in Appendix B.

4.0 EXPOSURE TEST

Section 4.3 of **SRCC Standard 100** requires solar collectors to undergo an outdoor no-flow exposure test. This test includes 30 days exposure (not necessarily consecutive) with a minimum of 17 megajoules of incident energy per square metre of collector surface area.

A written description of changes observed during the test is given in Appendix B. Insolation and ambient temperature data are recorded at half-hour intervals for the duration of the exposure period. Section 4.3.1 of **SRCC Standard 100** requires that the collector exposure conditions include at least one consecutive 4-hour period with a minimum instantaneous flux of 950 W/m² at an average ambient temperature of 27 °C or higher during the 4-hour period. This requirement could not be met outdoors due to current local weather conditions. The exposure interval which most closely matches these conditions occurred September 18, 2004 when there was a 3-hour period of solar irradiation >950 W/m² and an average outdoor air temperature of 19 °C.

The dates of the days on which the total incident energy in the plane of the collector exceeded 17 MJ/m² are also reported. The collector described in this report received its' exposure between the months of September and November, 2004.

5.0 THERMAL SHOCK / WATER SPRAY TEST

Section 4.4 of SRCC Standard 100 requires that for a five minute period on three different days of the exposure test the collector be subjected to heavy water spray after at least one hour exposure to direct sunlight (minimum 850 W/m² intensity). The water spray tests are done in the last 10 days of the exposure test, with a water delivery rate of at least 0.02 L/s/m² of collector area. Water temperature during the water spray tests is

maintained at 24 °C (± 5 C°). A report of the observations made during the test is included in Appendix B.

6.0 THERMAL SHOCK / COLD FILL TEST

Section 4.5 of SRCC Standard 100 requires that at one time during the test sequence the unfilled collector be exposed to full sunlight (950 W/m²) for a one hour period. Liquid is then circulated through the collector at a rate of at least 0.015 L/s/m² of collector area. Water temperature during the cold fill test is maintained at 24 °C (± 5 C°). A report of the observations made during the test is included in Appendix B.

7.0 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 the collector sample was determined in the solar simulator and in accordance with ANSI / ASHRAE Standard 93-86 (section 8.3.2). The initial radiation level was 887 W/m². The solar simulator was turned off when the collector inlet temperature stabilized near ambient temperature, and the change in temperature rise across the collector was recorded as a function of time. ANSI / ASHRAE Standard 93-86 defines the time constant as the time taken for the collector temperature rise to decrease to 0.368 of its initial value. The time constant for the collector described in this report was 15 minutes, 45 seconds at a flow rate of 0.056 kg/s using water. The collector fluid inlet temperature was 20.0 °C during the time constant test, with an ambient air temperature of 19.9 °C.

8.0 THERMAL EFFICIENCY

The sample was mounted directly to the liquid collector test frame. 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 ($m \cdot c_p$) 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 $m \cdot c_p$ 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 done in the solar simulator and in accordance with **SRCC Standard 100** “*Test Methods and Minimum Standards for Certifying Solar Collectors*”, which references ANSI / ASHRAE Standard 93-86. The collector plane was maintained normal to the direction of irradiation during thermal efficiency testing. Testing was performed at the standard flow rate of **0.055 kg/s** (0.018 kg/s • m²), at a measured average wind speed of **2.6 m/s**.

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

Efficiency in SI units based on gross area of **3.075 m²**:

$$1^{\text{st}} \text{ order fit: } \eta = 0.345 - 1.151 (T_i - T_a)/G$$

$$2^{\text{nd}} \text{ order fit: } \eta = 0.342 - 0.849 (T_i - T_a)/G - 0.0050 (T_i - T_a)^2/G$$

Efficiency in inch-lb units based on gross area of **33.10 ft²**:

$$1^{\text{st}} \text{ order fit: } \eta = 0.345 - 0.203 (T_i - T_a)/G$$

$$2^{\text{nd}} \text{ order fit: } \eta = 0.342 - 0.150 (T_i - T_a)/G - 0.0005 (T_i - T_a)^2/G$$

Power output from the collector for various conditions was calculated from the above 2nd order efficiency equation in SI units. The results are listed in Table 1.

Table 1: Power Output (Power in watts per collector, normal incidence, beam irradiation)

Solar Irradiance	400 W/m ²	700 W/m ²	1000 W/m ²
Ti-Ta = 10 °C	393	709	1024
Ti-Ta = 30 °C	329	644	959
Ti-Ta = 50 °C	252	567	883

9.0 INCIDENT ANGLE MODIFIER TESTS

The Incident Angle Modifier (IAM) is a measure of the deviation of the collector from cosine response. Incident angle modifier testing was done in accordance with section 8.3.4, method (1) of ANSI / ASHRAE Standard 93-86. Horizontal and vertical IAM tests were done. With the one exception noted below, during the IAM tests the collector was set successively at 0°, 30°, 45°, and 60° angles from normal incidence, while the solar simulator lamp beam was tilted approximately 30 degrees down from horizontal. When measuring the vertical IAM at 60° incidence, the solar simulator lamp beam was

horizontal, and the collector was tilted at 30° from horizontal to maintain the collector tubes at a slope, so that the heat pipes would function properly.

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, and the IAM values are listed in Table 2.

Note: In the configuration of the vertical IAM tests, the bottom of the collector tubes were necessarily closer to the solar simulator than the top of the collector tubes. This configuration resulted in higher irradiance at the bottom of the tubes than at the top of the tubes. Since the liquid in the heat pipes is at the bottom of the tubes, the higher irradiance at that location resulted in a higher overall collector performance than would be expected if the irradiance was uniform over the length of the tubes. For that reason, the measured vertical IAM data must be interpreted as an over-estimation of the vertical IAM that the collector would have when exposed to outdoor natural solar radiation.

Table 2: Incidence Angle Test Results.


	0° *	30°	45°	60°	90° *
Horizontal IAM (transverse to tubes)	1.0	1.13	1.38	1.51	0.0
Vertical IAM (longitudinal)	1.0	1.00	1.00	0.96	0.0

* Values quoted for 0° and 90 ° are defined IAM values rather than measured results.


10.0 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 not dismantled for the inspection. Each evacuated tube was inspected for failure after testing, and was found to be still silver at the bottom, indicating that its vacuum was intact. A report of the observations made during the final inspection is included in Appendix B.

Reported by:


for Larry West, C.E.T.
National Solar Test Facility

Reviewed by:


Dr. Alfred P. Brunger, P. Eng.
Manager,
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

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/m ²)
Gdn :	Direct beam solar radiation as measured by the normal incidence pyrhelimeter (W/m ²)
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/m ²)
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
Backwards to the Future Ltd.**

Date/Time	Len min.	G W/m ²	Gdn W/m ²	Ta °C	Ti °C	ΔT °C	Ws m/s	m·Cp W/°C	m* kg/s	Ti-Ta °C	(Ti-Ta)/G °C m ² / W	η	ΔP kPa
2004/12/15 16:14	5	797	n/a	20.1	20.0	3.64	2.6	230.2	0.0551	0.0	-0.0001	0.342	0.0
2004/12/15 16:19	5	801		20.1	20.0	3.67	2.6	229.7	0.0550	-0.1	-0.0001	0.342	
2004/12/15 16:24	5	799		20.1	20.0	3.68	2.6	229.5	0.0549	-0.1	-0.0001	0.344	
2004/12/15 16:38	5	794		20.1	20.0	3.65	2.6	229.8	0.0550	-0.1	-0.0001	0.344	
2004/12/16 9:45	5	796		20.1	40.0	3.39	2.6	228.0	0.0546	19.9	0.0250	0.315	0.0
2004/12/16 9:50	5	797		20.1	40.0	3.41	2.6	227.7	0.0545	19.9	0.0250	0.317	
2004/12/16 9:55	5	800		20.1	40.0	3.43	2.6	227.1	0.0543	19.9	0.0248	0.317	
2004/12/16 10:00	5	802		20.1	40.0	3.45	2.6	226.5	0.0542	19.9	0.0248	0.317	
2004/12/16 11:54	5	797		20.1	60.0	3.14	2.6	227.4	0.0544	39.9	0.0501	0.292	0.0
2004/12/16 11:59	5	796		20.2	60.0	3.13	2.6	227.6	0.0545	39.9	0.0501	0.291	
2004/12/16 12:04	5	798		20.1	60.0	3.15	2.6	227.7	0.0545	39.9	0.0500	0.292	
2004/12/16 12:09	5	798		20.1	60.0	3.13	2.6	227.9	0.0546	39.8	0.0499	0.291	
2004/12/16 13:09	5	797		20.1	80.0	2.77	2.6	226.8	0.0543	59.8	0.0751	0.256	0.0
2004/12/16 13:20	5	805		20.1	80.0	2.78	2.6	226.4	0.0542	59.9	0.0745	0.254	
2004/12/16 13:25	5	803		20.1	80.0	2.77	2.6	227.3	0.0544	59.9	0.0746	0.255	
2004/12/16 13:30	5	798		20.1	80.0	2.75	2.6	228.1	0.0546	59.9	0.0751	0.256	

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

Bodycote Sample No.: 04-08-0529
 Collector Model: SP-20
 Test Dates: Dec 15-16, 2004
 Test Fluid: water
 Mass Flow Rate: 0.055 kg/s
 Wind Speed (nominal): 2.6 m/s
 Gross Area: 3.075 m²
 Aperture Area: 2.007 m²
 Absorber Area: 1.56 m²
 Mean Ambient Temp.: 20.1 °C
 Irradiance Intensity: 799 W/m²

Curve Fit based on Gross Area:

1st Order (SI units):

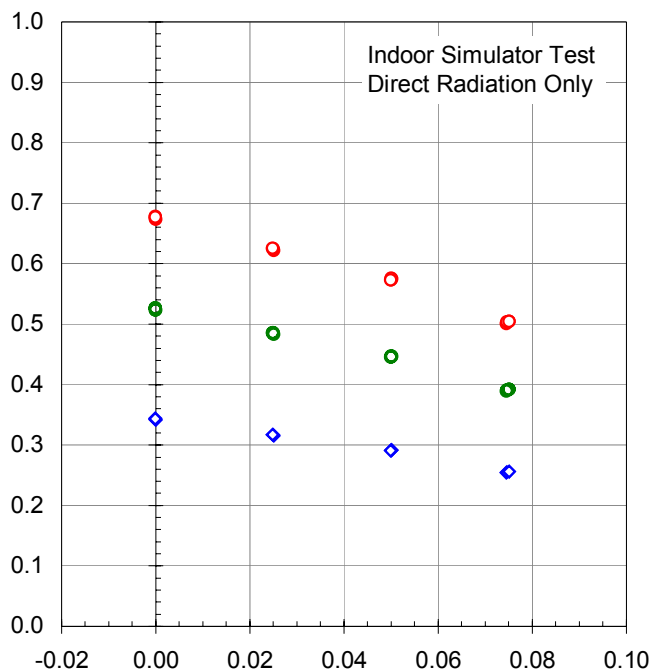
$$\eta = 0.345 - 1.151(Ti-Ta)/G$$

$$\eta = 0.342 - 0.849(Ti-Ta)/G - 0.0050(Ti-Ta)^2/G$$

1st Order (British units):

$$\eta = 0.345 - 0.203(Ti-Ta)/G$$

$$\eta = 0.342 - 0.150(Ti-Ta)/G - 0.0005(Ti-Ta)^2/G$$

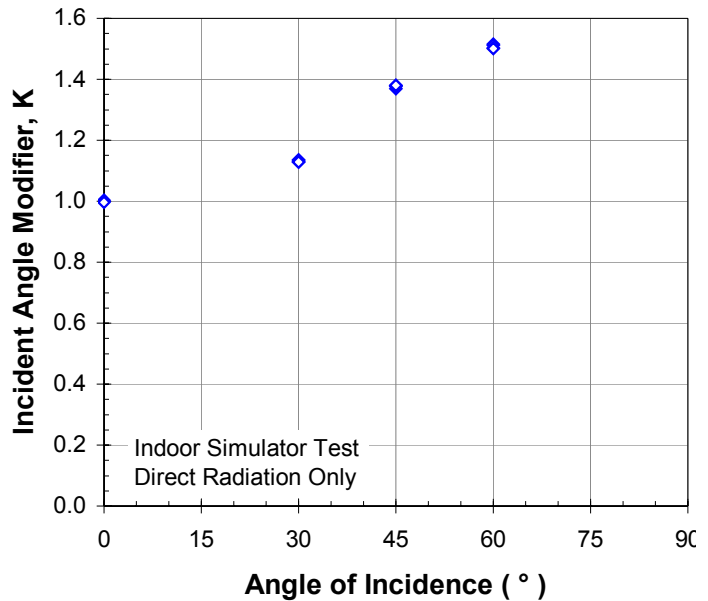


Horizontal Incident Angle Modifier Test Data
Backwards to the Future Ltd.

Date/Time	Len <i>min.</i>	G <i>W/m²</i>	Gdn <i>W/m²</i>	Ta <i>°C</i>	Ti <i>°C</i>	ΔT <i>°C</i>	m•Cp <i>(W/°C)</i>	m * <i>kg/s</i>	Ti-Ta <i>°C</i>	(Ti-Ta)/G <i>°C m²/ W</i>	η	K
θ = 0°												
2004/12/16 14:46	5	799	n/a	20.1	20.0	3.97	226.0	0.054	-0.1	-0.00015	0.365	1.005
2004/12/16 14:51	5	800		20.1	20.0	3.95	226.1	0.054	0.0	-0.00005	0.363	1.000
2004/12/16 14:56	5	803		20.1	20.0	3.95	226.6	0.054	-0.1	-0.00010	0.363	0.999
2004/12/16 15:01	5	801		20.1	20.0	3.93	226.2	0.054	-0.1	-0.00012	0.361	0.996
θ = 30°												
2004/12/16 15:35	5	709		20.4	20.0	3.95	227.3	0.054	-0.4	-0.00053	0.411	1.132
2004/12/16 15:40	5	709		20.3	20.0	3.95	227.3	0.054	-0.3	-0.00045	0.412	1.135
2004/12/16 15:45	5	711		20.4	20.0	3.95	226.7	0.054	-0.4	-0.00056	0.410	1.128
2004/12/16 15:50	5	711		20.4	20.0	3.96	226.2	0.054	-0.3	-0.00048	0.410	1.128
θ = 45°												
2004/12/16 16:18	5	597		20.5	20.0	4.00	228.4	0.055	-0.5	-0.00091	0.498	1.369
2004/12/16 16:23	5	597		20.5	20.1	3.98	230.6	0.055	-0.4	-0.00070	0.500	1.375
2004/12/16 16:28	5	596		20.5	20.0	4.02	229.0	0.055	-0.5	-0.00087	0.502	1.380
2004/12/16 16:33	5	596		20.5	20.0	4.02	228.5	0.055	-0.5	-0.00087	0.501	1.379
θ = 60°												
2004/12/16 17:25	5	419		20.7	20.0	3.11	228.3	0.055	-0.7	-0.00162	0.552	1.516
2004/12/16 17:30	5	419		20.7	20.0	3.10	228.9	0.055	-0.7	-0.00162	0.550	1.512
2004/12/16 17:49	5	419		20.7	20.0	3.08	228.8	0.055	-0.7	-0.00177	0.547	1.502
2004/12/16 17:55	10	420		20.7	20.0	3.08	228.8	0.055	-0.7	-0.00172	0.546	1.501

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

Bodycote Sample No.: 04-08-0529
 Collector Model: SP-20
 Test Date: 16/Dec/2004
 Test Fluid: water
 Mass Flow Rate: 0.055 kg/s
 Wind Speed (nominal): 2.6 m/s
 Mean Ambient Temp.: 20.4 °C
 Gross Area: 3.075 m²
 Aperture Area: 2.007 m²
 Absorber Area: 1.56 m²

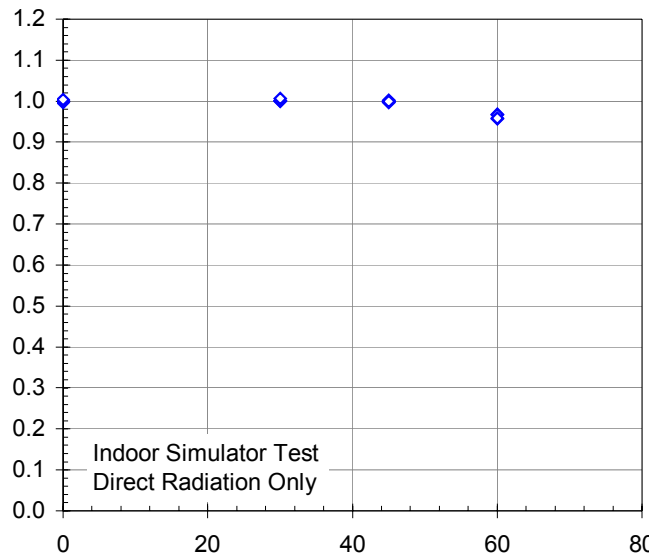


Vertical Incident Angle Modifier Test Data
Backwards to the Future Ltd.

Date/Time	Len min.	G W/m ²	Gdn W/m ²	Ta °C	Ti °C	ΔT °C	m•Cp (W/°C)	m * kg/s	Ti-Ta °C	(Ti-Ta)/G °C m ² / W	η	K
θ = 0°												
17/12/2004 10:52	5	800	n/a	20.0	20.0	3.79	226.0	0.054	0.0	-0.00003	0.348	0.996
17/12/2004 10:57	5	798		20.1	20.0	3.79	225.9	0.054	-0.1	-0.00013	0.349	0.999
17/12/2004 11:02	5	797		20.1	20.0	3.81	225.2	0.054	-0.1	-0.00008	0.350	1.001
17/12/2004 11:07	5	798		20.1	20.0	3.82	225.1	0.054	-0.1	-0.00008	0.351	1.004
θ = 30°												
17/12/2004 16:05	5	695		20.3	20.0	3.30	226.2	0.054	-0.2	-0.00032	0.349	0.999
17/12/2004 16:10	5	697		20.3	20.0	3.30	227.4	0.054	-0.3	-0.00037	0.350	1.001
17/12/2004 16:15	5	698		20.3	20.0	3.29	228.4	0.055	-0.3	-0.00040	0.350	1.001
17/12/2004 16:20	5	697		20.3	19.9	3.31	227.8	0.055	-0.3	-0.00049	0.352	1.006
θ = 45°												
17/12/2004 13:14	5	559		20.2	20.0	2.68	224.5	0.054	-0.2	-0.00032	0.350	1.002
17/12/2004 13:19	5	561		20.2	20.0	2.68	224.6	0.054	-0.2	-0.00036	0.350	1.000
17/12/2004 13:25	5	561		20.2	20.0	2.68	224.5	0.054	-0.2	-0.00036	0.349	0.997
17/12/2004 13:30	5	560		20.2	20.0	2.68	224.7	0.054	-0.2	-0.00036	0.350	0.999
θ = 60°												
17/12/2004 14:49	5	471		20.4	20.0	2.16	227.4	0.054	-0.4	-0.00076	0.339	0.968
17/12/2004 14:54	5	471		20.4	20.0	2.15	228.2	0.055	-0.4	-0.00085	0.339	0.967
17/12/2004 15:02	5	474		20.4	20.0	2.15	227.5	0.054	-0.4	-0.00093	0.335	0.956
17/12/2004 15:07	5	473		20.4	20.0	2.15	227.1	0.054	-0.4	-0.00080	0.336	0.958

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

Bodycote Sample No.: 04-08-0529
 Collector Model: SP-20
 Test Date: 17/Dec/2004
 Test Fluid: water
 Mass Flow Rate: 0.054 kg/s
 Wind Speed (nominal): 2.6 m/s
 Mean Ambient Temp.: 20.2 °C
 Gross Area: 3.075 m²
 Aperture Area: 2.007 m²
 Absorber Area: 1.56 m²



The vertical IAM test data over-estimate collector performance for natural sunlight.
 See note in Section 9.0.

APPENDIX B

(8 pages)

Static Pressure Test

Outdoor No Flow Exposure Test, Exposure Days

Outdoor No Flow Exposure Test, Inspection Report

Thermal Shock / Water Spray Test

Thermal Shock / Cold Fill Test

Second Static Pressure Test

Final Inspection

Liquid Collector Static Pressure Test
(SRCC standard 100, section 4.2)

General

BODYCOTE sample no.: 04-08-0529
Manufacturer: Backwards to the Future Ltd.
Model No.: _____
Tested by: Samy E. West Date: 2004-SEP-07

Test Pressure

Manufacturers' Recommended Working Pressure: _____ psi
Street Pressure: _____ psi
Test Pressure: 160 psi

Pressure Test

1) Before pressure applied: 0 psi
2) Immediately after pressure applied: 160 psi
3) 15 minutes after pressure applied: 160 psi
4) Immediately after pressure released: 0 psi

dP = Pressure (2) - Pressure (3) = 0 psi

Results

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

Approved by: Alfred Brunger Date: 2004-12-24

Outdoor No Flow Exposure Test

Month	Exposure Days - 2004	Totals
January	n/a	
February	n/a	
March	n/a	
April	5,9,10,11,12,14,15,16,20,22,23,24,26,28,29	15
May	4,5,6,7,10,11,12,13,14,16,17,19,26,27,28,29,30	17
June	n/a	22
July	n/a	17
August	1,2,3,5,8,9,10,14,16,19,21,22,23,24,25,31	16
September	1,2,3,4,6,10,11,12,14,15,18,19,20,21,22,23,24,26,27,29,30	21
October	1,3,5,6,7,8,10,12	8
November	3,5,6,12,13,14,15	7
December		

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	Start Date	End Date	Sample no.	Exposure Days
Backwards to the Future	2004/Sep/08	2004/Nov/13	04-08-0529	30

Outdoor No Flow Exposure Test
(SRCC standard 100, section 4.3)

General

BODYCOTE sample no.: 04-08-0529
 Manufacturer: Backwards to the Future
 Model No.: SP-20
 Exposure commencement: 10:30 Am Date: 2004-SEP-08

Inspections (weekly)

Date	Initials	Observations of Changes
2004-09-13	SW	plugs have moved upwards
2004-09-20	SW	one grommet partly pushed out.
2004-09-27	SW	no change.
2004-10-04	SW	" "
2004-10-12	SW	" "
2004-10-18	SW	" "
2004-10-25	SW	" "
2004-11-01	SW	" "
2004-11-08	SW	" "
2004-11-15	SW	" "
<hr/>		

Exposure test termination: 2004-NOV-15

Reason: exposure completed
 structural damage

Approved by: Alfred Brunger Date: 2004-12-24

Liquid Collector Thermal Shock / Water Spray Test
(SRCC standard 100, section 4.4)

General

BODYCOTE sample no.: 04-08-0529
Manufacturer: Backwards to the Future
Model No.: SP-20
Recommended Working Fluid: Water
Tested by: Samy E. West Test Duration: 5 min.
Solar Irradiance: 850 W/m² for at least 1 hour previous to test

Test 1:

Test start time: 12:05 Date: 2004-10-07
Flow rate 0.020 L/s/m² of collector area: ~4 LPM ~10 LPM *
Water temperature (24 ± 5 °C): 25

Test 2:

Test start time: 12:50 Date: 2004-10-08
Flow rate 0.020 L/s/m² of collector area: ~8 LPM
Water temperature (24 ± 5 °C): 25

Test 3:

Test start time: 11:38 Date: 2004-10-12
Flow rate 0.020 L/s/m² of collector area: ~10 LPM
Water temperature (24 ± 5 °C): 25

Visible signs of leakage:

YES

NO

Description of leakage (if any):

Approved by: Alfred Benzger

Date: 2004-12-24

Liquid Collector Thermal Shock / Cold Fill Test
(SRCC standard 100, section 4.5)

BODYCOTE sample no.: 04-08-0529
Manufacturer: Backwards to the Future
Model No.: SP-20
Recommended Working Fluid: water
Fill Rate (0.015 L/s/m² of collector area): 2.9 L/m
Water Temperature (24 ± 5 °C): 26
Tested by: Jerry E West Date: 2004-10-26

Start time for Insolation Period (minimum 1h at 950 W/m²): 11:55
Earliest test time: 12:55
Test start time: 12:57
Test completion time: 13:02

Visible signs of damage: YES **NO**

Description of damage (if any):

Approved by: Alfred Bringer Date: 2004-12-24

Liquid Collector Static Pressure Test
(SRCC standard 100, section 4.2)

General

BODYCOTE sample no.: 04-08-0529
Manufacturer: BTF Soltec LTD.
Model No.: SP-20
Tested by: Jerry E. West Date: 2004-NOV-16

Test Pressure

Manufacturers' Recommended Working Pressure: _____ psi
Street Pressure: _____ psi
Test Pressure: 160 psi

Pressure Test

1) Before pressure applied: 0 psi
2) Immediately after pressure applied: 160 psi
3) 15 minutes after pressure applied: 160 psi
4) Immediately after pressure released: 0 psi

dP = Pressure (2) - Pressure (3) = 0 psi

Results

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

Approved by: Alfred Bruggen Date: 2004-12-24

Liquid Collector Final Inspection
(SRCC standard 100, section 4.10)

FSEC 00144

BODYCOTE sample no.: 04-08-0529

Model: SP-20

Inspected by: Alfred Brunger

Inspection Date: 2004-12-24

Collector Case / Enclosure / Fasteners:

No visible degradation [] Cracking / Warping / Corrosion

Mounting Means (mounting brackets, flanges, etc.):

No visible degradation [] Loss of mounting integrity

Seals / Gaskets:

No visible degradation [] Cracking / Loss of Elasticity, Adhesion

Cover(s) / Reflectors:

No visible degradation [] Cracking / Crazing / Buckling /
Delamination / Warping / Hazing

Absorber:

1. Coating:

No visible degradation [] Cracking / Crazing / Blistering

2. Inlet / Outlet Tubes:

No visible degradation [] Deformation / Corrosion / Leakage

3. Flow Tubes:

No visible degradation [] Deformation / Corrosion / Leakage / Loss of
Bonding

4. Headers:

No visible degradation [] Deformation / Corrosion / Leakage

5. Absorber Mountings:

No visible degradation [] Loss of mounting integrity

Insulation:

No visible degradation [] Water Retention / Swelling / Outgassing

Approved by: Alfred Brunger

Date: 2004-12-24