SOLAR RATING & CERTIFICATION CORPORATION™

An ICC Evaluation Service Program

OG-100 Solar Thermal Collector Certification No./10002155

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CERTIFICATION HOLDER:	**EVALUATION SUBJECT**	
SunEarth, Inc. 8425 Almeria Avenue Fontana, CA 92335 USA www.sunearthinc.com	**BRAND:**	ThermoRay
	MODEL:	TR-40
	TYPE:	Flat Plate Glazed Liquid Heating Collector

PRODUCT CERTIFICATION SYSTEM:

The ICC-SRCC OG-100 certification program includes evaluation and performance ratings for solar thermal collectors as established in the *ICC-SRCC Rules for Solar Heating & Cooling Product Listing Reports.* The program also includes periodic factory inspections and surveillance of the manufacturer's quality management system.

COMPLIANCE WITH THE FOLLOWING STANDARD(S): *ICC 901/SRCC 100 - 2020, Solar Thermal Collectors Standard*

OG-100 THERMAL PERFORMANCE RATINGS:

ICC-SRCC OG-100 thermal performance ratings provided for the collector are calculated for a 24-hour period using OG-100 standard conditions using collector parameters measured through laboratory testing. Actual performance will vary with local conditions, installation details and usage.

OG-100 STANDARD DAILY PRODUCTION TABLE

Kilowatt-hours (thermal) per Collector per Day				**Thousands of BTU per Collector per Day**			
Climate → **Category** **(T_i-T_a)**	High Radiation (6.3 kWh/m²•day)	Medium Radiation (4.7 kWh/m²•day)	Low Radiation (3.1 kWh/m²•day)	**Climate →** **Category** **(T_i-T_a)**	High Radiation (2 kBTU/ft²•day)	Medium Radiation (1.5 kBTU/ft²•day)	Low Radiation (1 kBTU/ft²•day)
A (-5˚C)	16.11	12.27	8.45	**A (-9˚F)**	54.97	41.85	28.84
B (5˚C)	13.92	10.08	6.27	**B (9˚F)**	47.49	34.39	21.39
C (20˚C)	10.69	6.92	3.35	**C (36˚F)**	36.48	23.61	11.44
D (60˚C)	4.51	1.53	0.00	**D (90˚F)**	15.39	5.22	0.00
E (80˚C)	0.14	0.00	0.00	**E (144˚F)**	0.48	0.00	0.00

A – Pool Heating (Warm Climate) **B** – Pool Heating (Cool Climate) **C** – Water Heating (Warm Climate) **D** – Space & Water Heating (Cool Climate) **E** – Commercial Hot Water & Cooling

THERMAL EFFICIENCY:

The efficiency of solar thermal collectors is determined using test methods set in ICC 901/SRCC 100, based on ISO 9806 procedures. Results are processed to provide unique coefficients ($\eta_{0,hem}$, a_1, a_2…) for efficiency equations, provided in several forms below. For the simplified equations, instantaneous power at normal incidence is given by $\dot{Q} = \eta_{hem} A_G G$. Incident Angle Modifiers (IAMs) are also provided to indicate the change in output as the angle of solar irradiance changes in the transverse and longitudinal planes of the collector. The three forms should provide similar results, but the extended form is considered the most accurate. Users should select the equation to be used based the application and available data.

T_i: Temperature of the fluid entering the collector.
T_m: Average temperature of the fluid within the collector (between the inlet and outlet).
T_a: Temperature of the ambient air around the collector.
G: Hemispherical solar irradiance. Sub-types include beam (b) and diffuse (d) irradiance.
E_L: Longwave (infrared) irradiance.

RATING CONDITIONS	
Gross Collector Area (A_G)	3.800 m²
Fluid Mass Flowrate ($\dot{m}$)	0.019 kg/(m²s)
Test Fluid	Water
Performance Test Standard	ISO 9806-2017

Thermal efficiency performance determined using the conditions and test methods in the standard listed above. All forms of efficiency equations are based on the rating conditions above.

SIMPLIFIED THERMAL PERFORMANCE EQUATIONS (ISO 9806-2013, T_i, A_G)

Second Order Thermal Efficiency Equation*

$$\eta_{hem} = \eta_{0,hem} - a_1 \frac{T_i - T_a}{G} - a_2 G \left(\frac{T_i - T_a}{G}\right)^2$$

Linearized Thermal Efficiency Equation*

$$\eta_{hem} = \eta_{0,hem} - a_1 \frac{T_i - T_a}{G}$$

UNITS	$\eta_{0,hem}$	a_1	a_2	$\eta_{0,hem}$ ("Intercept")	a_1 ("Slope")
SI	0.695	4.946 W/(m²K)	0.0298 W/(m²K²)	0.709	6.801 W/(m²K)
IP	0.695	0.872 BTU/(h ft²°F)	0.0029 BTU/(h ft²°F²)	0.709	1.199 BTU/(hr ft²°F)

** Thermal efficiency equations per ISO 9806-2013 using inlet (Ti) fluid temperature, provided in second and first order (linearized) forms for normal incidence. The second order efficiency equation is a more accurate representation of the collector performance than the linearized equation. The linearized efficiency equation is provided for use with incentive programs, regulations and software that require the simplified "slope" and "intercept" coefficients to describe collector performance.*

GENERAL THERMAL PERFORMANCE EQUATION (ISO 9806-2017, T_m, A_G)

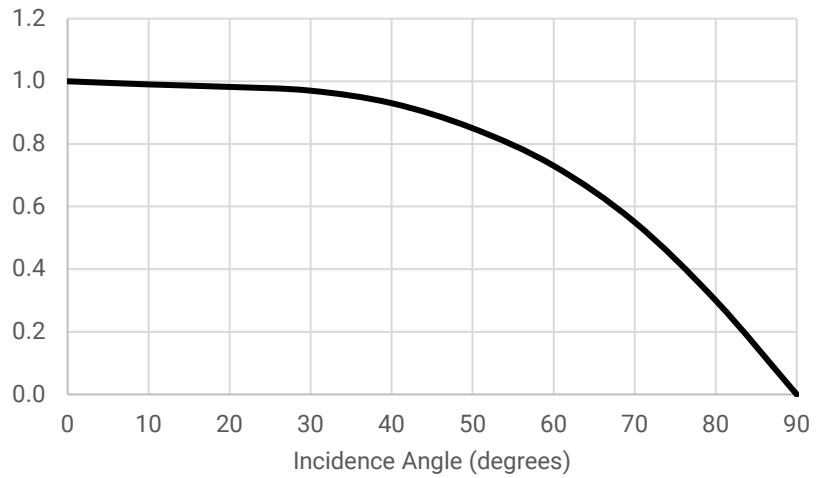
Extended Thermal Efficiency Equation**

$$\dot{Q} = A_G(\eta_{0,b} K_b(\theta_L, \theta_T) G_b + \eta_{0,b} K_d G_d - a_1(T_m - T_a) - a_2(T_m - T_a)^2 - a_3 u'(T_m - T_a) + a_4(E_L - \sigma T_a^4) - a_5\left(\frac{dT_m}{dt}\right) - a_6 u' G - a_7 u'(E_L - \sigma T_a^4) - a_8(T_m - T_a)^4$$

	$\eta_{0,b}$	K_d	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	σ
VALUE	0.733	0.814	4.775	0.034	0.000	0.000	5269	0.000	0.000	0.000	5.670 x 10^{-8}
UNITS	-	-	W/(m²	W/(m²	J/(m³K)	-	J/(m²K)	s/m	W/(m²K⁴	W/(m²K⁴	W/(m²K⁴)

*** General thermal efficiency equation for mean (T_m) fluid temperature provided in accordance with ISO 9806-2017. Where data measured using a standard other than ISO 9806-2017, additional assumptions may be applied to determine extended equation coefficients. Reduced surrounding air speed (u') is defined as u'=u-3 m/s. See ISO 9806-2017 for other coefficient definitions.*

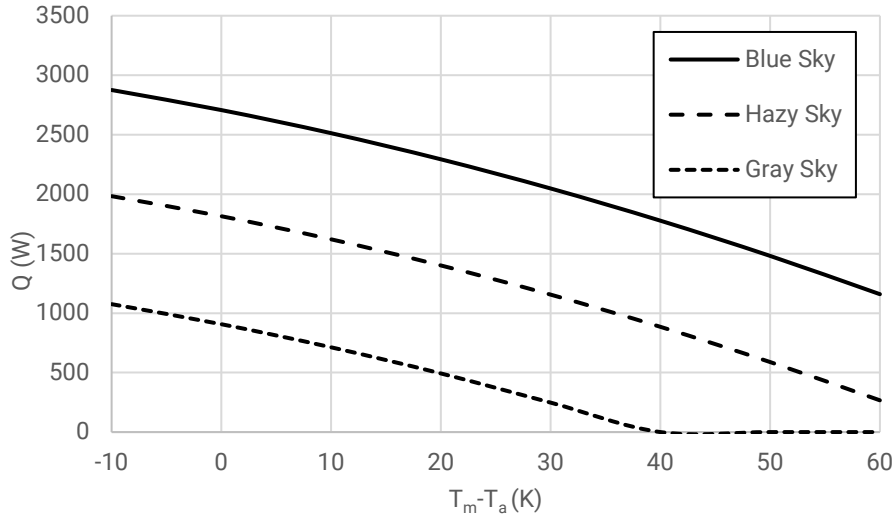
DIRECT INCIDENT ANGLE MODIFIERS (IAM)



Angle (θ)	IAM ($K_b(\theta)$)
0°	1.00
10°	0.99
20°	0.98
30°	0.97
40°	0.93
50°	0.85
60°	0.73
70°	0.55
80°	0.30
90°	0.00

POWER OUTPUT:

The instantaneous power output of the collector under different conditions is calculated at the Standard Reporting Conditions (SRC) defined by ISO 9806-2017 using the measured performance coefficients above.



STANDARD COLLECTOR POWER OUTPUT (W)			
Based on Standard Rating Conditions (SRC) and mean temperature (T_m) in accordance with ISO 9806-2017			
T_m-T_a (°C)	**Blue sky** G_b = 850, G_d = 150 (W/m²)	**Hazy sky** G_b= 440, G_d= 260 (W/m²)	**Grey sky** G_b=0, G_d= 400 (W/m²)
-10	2875	1983	1075
0	2707*	1815	907
10	2513	1620	713
20	2293	1401	493
30	2048	1155	248
40	1777	885	0
50	1481	589	0
60	1159	267	0

**Peak Power is defined by ISO 9806 as the Blue Sky irradiance condition at T_m-T_a =0 and normal incidence.*

TEST SAMPLE SPECIFICATIONS:

The specifications of the collector sample submitted for testing are provided below.

TEST & SAMPLE SPECIFICATIONS					
Gross Length:	3.10 m	10.2 ft	**Maximum Design Temperature:**	80 °C	176 ˚F
Gross Width:	1.22 m	4.0 ft	**Maximum Design Pressure:**	1103 kPa	160 psi
Gross Depth:	85.0 mm	3.4 in	**Standard Stagnation Temperature:**	156 °C	313 ˚F
Empty Weight:	59.5 kg	131 lb			
Fluid Capacity:	4.5 L	1.2 gal			
Notes:	Standard stagnation at 1000 W/m² and 30 °C as defined by ISO 9806 – 2017.				

IDENTIFICATION:

Certified collectors must be labeled in accordance with the *ICC-SRCC Rules for Certification Mark and Certificate Use*. Labels must contain information as specified in the standard listed above.

CONDITIONS:

1. Collector must be installed and operated in accordance with the manufacturer's published instructions and local codes and regulations.
2. OG-100 Standard Performance Ratings and Standard Collector Power Output have been calculated for the tested components using standardized conditions established by the OG-100 program and associated test standards. Actual performance will vary based on the specific usage, installation and local environmental conditions.
3. The collector listed in this ICC-SRCC OG-100 certification must be labeled in accordance with the *ICC-SRCC Rules for Mark and Certificate Use*.
4. OG-100 certifications do not include mounting hardware and fixtures.
5. Solar thermal collectors and mounting hardware and appurtenances must comply with all applicable local requirements for fire resistance. Solar thermal collectors must be mounted in accordance with the requirements of the collector and mounting hardware manufacturers to comply with local codes for structural loading for wind, seismic, snow and other loads.
6. Solar thermal collectors must be used with the heat transfer fluids listed in this document.
7. Solar thermal collector manufactured under a quality control program subject to periodic evaluation in accordance with the requirements of ICC-SRCC.
8. This document must be reproduced in its entirety.
9. Certification status should be confirmed on the ICC-SRCC Directory at www.solar-rating.org

Shawn Martin

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CERTIFICATE # 3299.01, 3299.03