Solar Boiler™

Solar Domestic Hot Water System
Technical Specifications

Thermo Dynamics Ltd.
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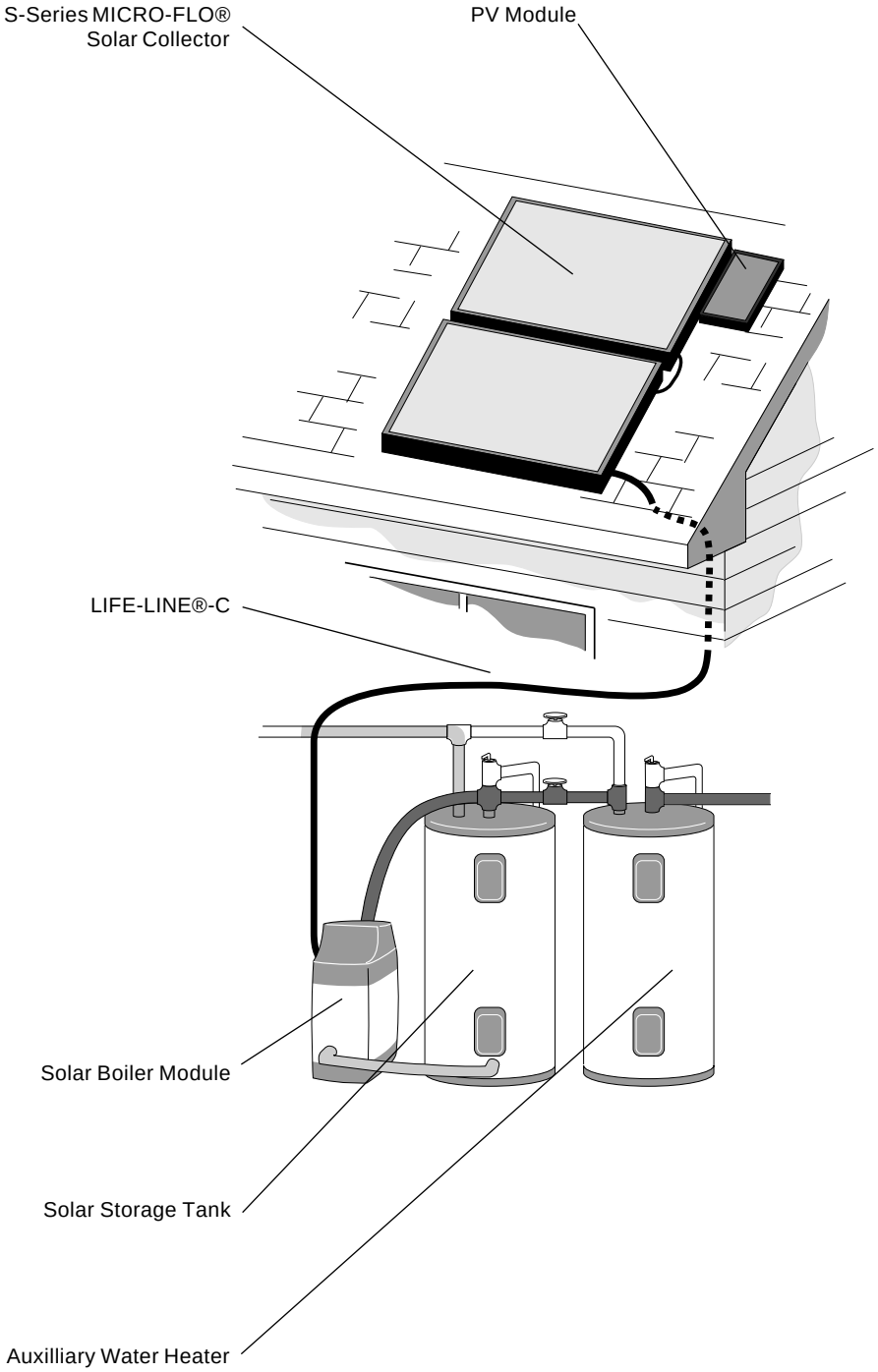


A. General Information

1.0 System Description:
The Thermo Dynamics Solar Boiler™ system is a revolutionary concept in solar domestic water heating systems. It is a solar preheat system using the external Side-Arm™ heat exchange system pioneered by Thermo Dynamics and the Micro-Flo® collector system for unsurpassed heat exchange efficiency.

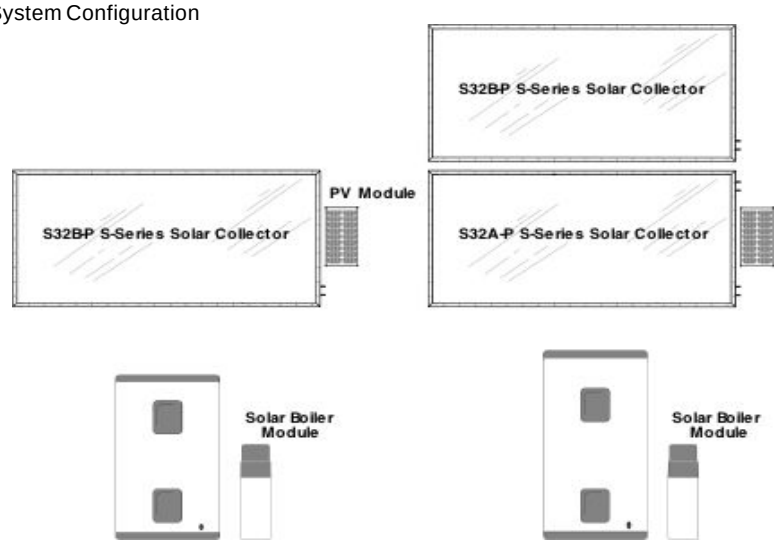
1.1 Warranties:
Thermo Dynamics Ltd. warranties the Micro-Flo® collectors and Solar Boiler™ heat exchange module for ten (10) years, all other components are warranted for one (1) year.

1.2 System Options:
Micro-Flo® collectors are available in 1.2m x 2.4m, (4' x 8'). The Solar Boiler™ system can have either one or two Micro-Flo® collectors installed. Collector mounting hardware is available for either sloped or flat roof installations.

2.0 Product Use:
Year round domestic and small commercial hot water preheat systems. Ideal for remote locations where power electrical power consumption is limited or unavailable.

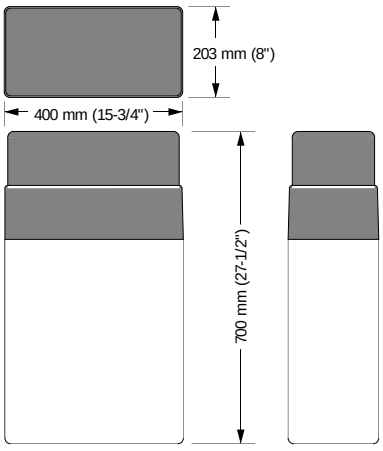
2.1 Geographic and Climatic Limitations:
None. Double freeze protection, using antifreeze and draindown, protects the system in cold climates. In hot climates over temperature protection is provided by inhibited glycol coupled with draindown and thermostatic tank protection.

System Configuration



SB32-9PV SB64-9PV

System	Collectors	Surface Area	Boiler Module	DHW Load	Recommended Solar Storage
SB32-9PV	1 - S32A	2.97 m2 (32 ft2)	SBM-9DC	<250 L/day	273 L (80 USG)
SB64-9PV	1 - S32A	5.82 m2 (64 ft2)	SBM-9DC	>250 L/day	454 L (120 USG)
	1 - S32B				



Solar Boiler Module (SBM-9DC)

3.0 Thermo Dynamics Ltd.'s Experience:

Thermo Dynamics Ltd. (TDL) is a Canadian company engaged in the research, development, production, distribution and installation of solar thermal equipment. The company has been involved in the solar thermal industry since 1981 and operates from its head office and factory in Dartmouth, Nova Scotia, Canada, the sister city of Halifax situated on the Atlantic coast. The company's specialization is the glazed liquid-flat-plate (LFP) collectors with metal absorbers. TDL is a fully integrated solar thermal company with the ability to convert raw aluminum and copper into a high technology solar water heating system.

Thermo Dynamics Ltd., as a world leader in solar technology, manufactures and markets solar heating equipment from complete systems to basic selective surface components for O.E.M.'s licensees, dealers and distributors through out North America, Europe, Africa, New Zealand, as well as 10 other countries around the world.

4.0 System Configuration:

The Solar Boiler™ is available in two formats:

SB32-9PV
SB64-9PV

All systems come with a Solar Boiler™ module, S-Series collector(s), a tubing kit to connect the Solar Boiler™ module to the collector, and a flush mounting kit for the collector. Storage tanks are supplied by the customer. The storage tank must have 1 unused port at the top of the tank and one unused port at the bottom of the tank.

4.1 Shipping Information:

System:	Weight:
SB32-9PV	94 kg (206 lbs)
SB64-9PV	141 kg (310 lbs)

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B. Collector Array

1.0 Micro-Flo® Collectors:
Thermo Dynamics S32 flat plate liquid collectors are single glazed with low-iron tempered glass. The absorber consists of a single serpentine aluminum fin with an integral copper tube , which is completely surrounded by the aluminum and metallurgically bonded together. The back and sides are insulated with a 25 mm (1") layer of compressed fiberglass. The collector frame is extruded aluminum with a baked-enamel finish, (dark brown). Collector mounting is by way of a sliding bolt-track. Flush and racked collector mounting formats are easily accommodated.

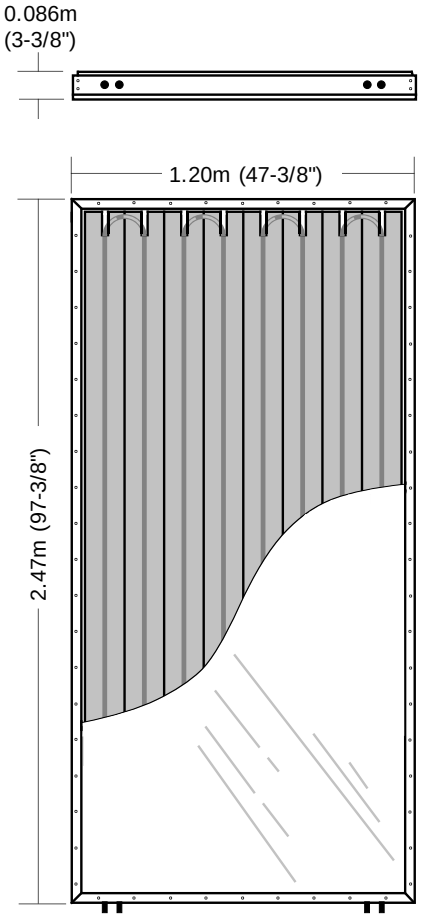
1.1 Options:
Factory installed temperature sensors; absorber coatings: selective Anodic-Cobalt™ surface, or semi-selective paint surface.

1.2 Dimensions:
S32: 1.20 m x 2.47 m x 0.086 m
(47-3/8 in x 97-3/8 in x 3-3/8 in)
Gross area: 2.96 m^2 (31.9 ft^2)
Aperture area: 2.78 m^2 (30.0 ft^2)
Absorber area: 2.87 m^2 (30.9 ft^2)
Liquid capacity: 0.389 L (0.086 IG)

1.3 Weight:

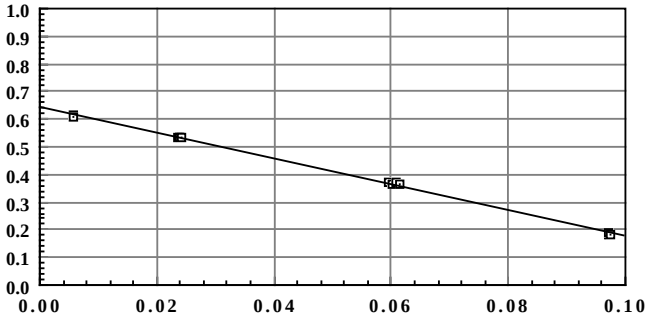
Model	Net	Shipping
S32	45 kg (99 lb)	47 kg (104 lb)

1.4 More Information:
See the Thermo Dynamics publication "S Series Solar Collectors - Technical Specifications (TC.201.00.MAR/94)" for more complete specifications on the Micro-Flo® collectors.



S32

Collector Thermal Efficiency



(Fluid inlet temperature - ambient air tempearature)/insolation rate [C/W/m2]

C. Liquid Handling System

1.0 General Description:
The Solar Boiler™ module is a Shell and Coil™ all copper heat exchanger and glycol reservoir. The heat transfer fluid in the solar loop circulates from the reservoir to the solar collectors and back through the coils of the heat exchanger by a positive displacement pump. The solar loop is closed from the atmosphere. A 862 kPa (125 psi) pressure relief valve is installed for safety. Circulation on the shell or water side of the heat exchanger is generated by natural circulation.

2.0 Principles of Operation:

2.1 Freeze Protection:
Freeze protection is provided by a solution of 40% Propylene Glycol USP and 60% distilled water in the solar loop. Propylene glycol does not freeze at the nominal freezing point (Freezing point -19°C (-2.4°F). The water in the system starts to form ice crystals and pumping becomes difficult. The 40/60 aqueous solution of Propylene Glycol provides burst protection to -51°C (-60°F).

2.2 Contamination Protection:
The Solar Boiler™ module operates at atmospheric pressure. The storage tank is at city water pressure and the water will flow into the Solar Boiler™ module if there is a leak in the heat exchanger, diluting and dispelling the small volume of heat transfer fluid from the system. Propylene glycol is nontoxic food grade approved heat transfer fluid requiring a single wall heat exchanger.

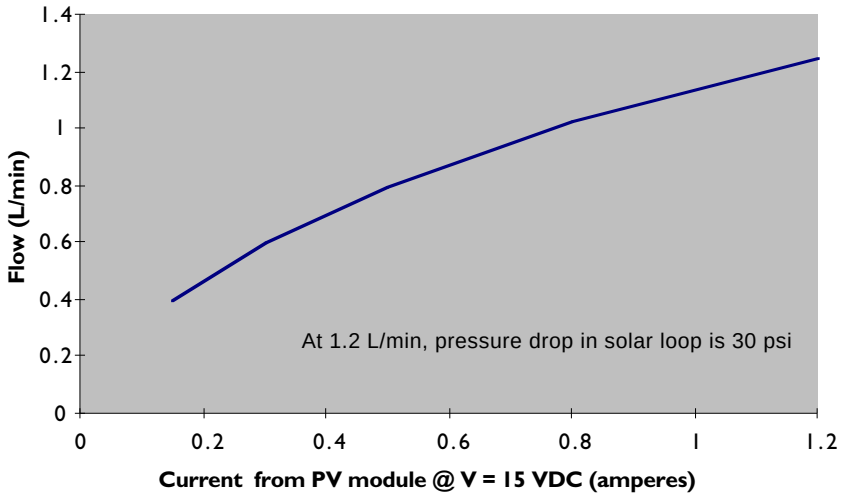
2.3 Leak Detection:
The glycol reservoir in the Solar Boiler™ module will overflow onto the floor. Propylene glycol is clear (older propylene glycol may be slightly green and/or brown). The fluid has an oily, slippery feeling when rubbed between your fingers.

2.4 High Temperature Limit:
A high temperature limit sensor installed on the storage tank prevents the storage tank from exceeding 82°C (180°F). An adjustable tempering valve can be installed on the hot water outlet if required by the local plumbing code.

2.5 Over Temperature Protection:
The boiling point of 40/60% aqueous solution of Propylene glycol/distilled water is 105°C (221°F). The maximum recommended bulk temperature is 163°C (325°F) and the maximum recommended film temperature is 191°C (375°F). The Solar Boiler™ is equiped with a 858 kPa, (125 psi) pressur relief valve (PRV) on the solar loop. In the event of a pump failing to circulate the glycol on a hot sunny day, the glycol expands in the solar collector, increasing the pressure in the solar loop, and thereby increasing the boiling point of the glycol to prevent boiling.

2.6 Corrosion Protection:
In the collector loop, the propylene glycol, when the pH is approximately 7, is non aggressive. All wetted parts are copper, stainless steel, carbon and brass.

Solar Pump™ model # P24070 - Flow vs Current
(2 Micro-Flo® solar collectors in series)



3.0 Pump Description:
The Solar Pump™ is a brass body, vane-type, positive displacement pump. The pump has special clearances and ethelyene-propylene seals for high temperature protection. It has a maximum output pressure of 500 kPa (73 psi). The nominal flow rate is 1.2 L/min. (0.32 USGPM). The pump has an integral built in strainer to remove any foreign particles from the solar loop. The pump is driven with an efficient DC motor. Nominal power consumption is 18 watts (1/40hp).

3.1 Maximum Operating Temperature:
88°C (190°F)

3.2 Maximum Operating Pressure:
500 kPa (73 psi)

4.0 Piping:
The connection between the Solar Boiler™ module and the solar collectors is made with soft copper tubing

4.1 Copper Tube Kit:
A copper tube kit is supplied for connecting the solar collectors to the Solar Boier™ module. The kit consists of two 9.53 mm (3/8") copper tubes, Armaflex™ foam insulation, and 16/2 communication wire. The insulation is put on the copper tubing on site by the installer.

4.2 LIFE-LINE®-C (OPTIONAL):
LIFE-LINE®-C. LIFE-LINE®-C consists of two 9.53 mm (3/8") copper tubes. The tubing is insulated with non-hygroscopic glass fibre insulation and has a light gray PVC jacket. Two 14 gauge communication wires are included in the bundle.

LIFE-LINE®-C is capable of withstanding working fluid temperature of 200°C (392°F) and pressure of 1.72 MPa (250 psi). The heat loss coefficient is 0.144 W/m-°C (0.083 Btu/hr ft-°F).

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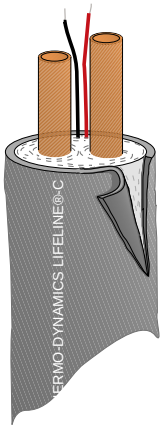
D. Controls

1.0 General Description:
The Solar Boiler™ uses a proportional control strategy, achieved by the variable output of a 18W photovoltaic module. The variable collector flowrate and thermosyphonic flow between the Solar Boiler™ and the storage tank ensure that high quality water is supplied to the auxiliary heater throughout the year. The PV module drives the DC motor through a linear current booster to ensure good performance at low light levels.

2.0 PV Module:
The Solarex PV module is used to drive the DC motor. The module has 36 single-crystal silicon solar cells connected in series, and weighs 2.95 kg (6.5 lb) and has outside dimensions of 421 mm (16.6") x 502mm (19.8"). The modules electrical specifications are:

Current at Peak Power	1.17 A
Voltage at Peak Power	17.1 DCV
Typical Peak Power	18.0 W
Short Circuit Current	1.19 A
Open Circuit Voltage	20.8 DCV

3.0 Linear Current Booster:
The Solar Boiler™ uses a Linear Current Booster to match the power delivery of the PV module to the DC motor under varying light condition. At peak irradiance the PV module runs the motor at rated speed, at lower light levels the LCB transforms the voltage into current to allow the motor to start. The motor runs at reduced speed at lower light levels providing a proportional control for the Solar Boiler™.



LifeLine®-C2 (optional)

E. Heat exchanger and tank

1.0 General Description:
The Solar Boiler™ uses Thermo Dynamics high performance Shell-and-Coil™ heat exchanger mounted in the Side-Arm™ configuration. This system provides a highly stratified storage tank. The storage tank can be any commercially available tank with the correct connections.

2.0 Heat Exchanger

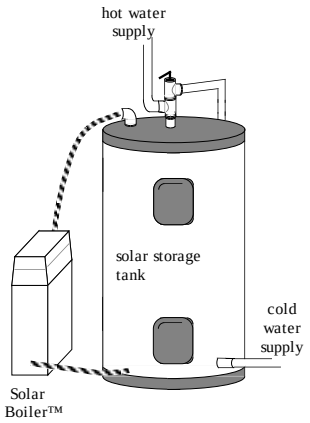
2.1 Materials
Shell-and-Coil™ heat exchanger is manufactured entirely from copper. The heat exchanger consists of several copper coils enclosed in a copper shell. All connections are brazed and are external to the shell.

2.2 Thermal Performance
The Solar Boiler™ utilises a high performance, Shell-and-Coil™ heat exchanger. Heat transfer area: 0.61 m2 (6.5 ft2). Overall heat transfer coefficient: 380 W/m2•K (67 Btu/h•ft2•°F).

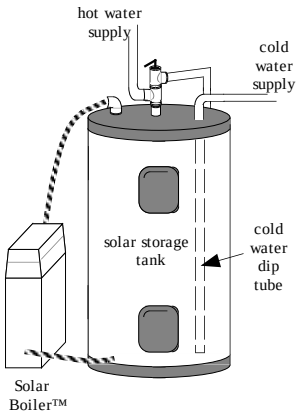
2.3 Durability
Hot water in contact with copper tubing has shown a life expectancy in excess of 30 years. Corrosion inhibitors on the propylene glycol heat transfer fluid offer excellent protection in the collector loop.

2.4 Pressure Rating:
The Shell-and-Coil™ heat exchanger is tested to 300 psi on the city water side and 120 psi on the collector side.

3.0 Storage Tank
The Solar Boiler™ module is designed to work with many commercially available storage tanks. Minimum solar storage is 272 L (72 USG) of water. Tanks must be suitable for hot water service and have at least 2 ports (19 mm, 3/4") at the top of the tank and one bottom port. Most electric water heater tanks are suitable. Electric elements must not be activated.



Two Port Tank



Three Port Tank

F. Heat Transfer Fluid

1.0 Genral Description
The propylene glycol, used in the Solar Boiler™, is a non toxic, food grade approved heat transfer fluid. It is commonly used in the food industry for high speed freezing of meats and poultry through direct immersion in the fluid, as well as an additive in many food items such as salad dressings, vanilla extract, etc.

2.0 Chemical Composition:
Solution of Propylene Glycol, USP and distilled water.

Composition:	40% Propylene glycol
(% by volume)	60% distilled water
pH:	7.0
Colour:	clear

The Solar Boiler™ module contains 4L of the Propylene glycol/distilled water mixture.

3.0 Fire Safety:
No flash point and noncombustible

4.0 Toxicity:
Propylene Glycol heat transfer fluid is generally recognized by the Food and Drug Administration (FDA) as a food additive under Part 182 and 184 of the Food Additive Regulations. The regulation for propylene glycol is 21CFR 184.1666.

5.0 Durability:
Maximum anticipated life span is 5 to 15 years.

G. Installation

1.0 Packaging:
The Solar Boiler™ system is shipped in three or four boxes depending on the collector configuration. One for the Solar Boiler™ module, one for the LIFELINE® tubing, and one or two for the solar collectors.

1.1 Labour and Equipment:
Two (2) men with a ladder and rope can easily mount collectors. The system may be installed with normal plumber's and carpenter's tools. Special tools are not required. The LIFELINE® flexible tubing, with the prepackaged components, reduces installation time 2 1/2 - 4 hours with an experienced crew.

2.0 Connection with Water Supply:
Install a back flow preventer and tempering valve if required by local plumbing code.

H Maintenance

1.0 General Description:
The installation manual, with maintenance and troubleshooting procedures, is supplied with systems.

2.0 System Shut-Down and Start-Up:

The system does not need to be shut down for vacation or winter periods. Initial system start-up should be carried out in early morning or late evening when the collectors are not under stagnation conditions.

3.0 Cleaning and Maintenance:

Check for fluid loss in the collector loop every year. Check the pH of the collector loop fluid annually, and replace it if not between 6.0 and 7.0. Replace the collector fluid every five to fifteen years. The storage tank should be drained every year to prevent sedimentation. The backflushing procedure for the heat exchanger must be followed every year. The backflushing procedure is listed under the top of the Solar Boiler™ and in the installation manual.

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I Solar Thermal Performance Canada:

1.0 Test Method:
CSA F379.1-M1988, ASHRAE 95-81

1.1 Location:
National Solar Test Facility, Mississauga, Ontario. Date: October 7, 1991.

1.3 Details of System:
Model: SB64-9PV
Solar Collectors: 2 - S32
Collector Area: 5.93 m^2 (63.83 ft^2)
Tank: Rheem 270 L (60 IG) with 25.4 mm (1") Fibreglass tank wrap
Heat Exchanger: Shell-and-Coil™
Heat Transfer Fluid: Water
Controls: LCB and PV module
Pump: Procon 1505 XF

2.0 Test Conditions:
System tested on indoor test bench using solar simulator.

2.1 Collector Tilt:
Normal to incident radiation

2.2 Ambient Temperature:
Tank: 20°C (68°F)
Collectors: 15°C (59°F)

2.3 Windspeed:
Day: 3.5 m/s (11.5 ft/s)
Night: 1.5 m/s (4.9 ft/s)

2.4 Hot Water Load:
300 L/Day @ 55°C. (66 IG/DAY @ 131°F)

2.5 Total Daily Solar Radiation:
63.83 MJ (60.50 MBtu)

2.6 Solar Output:
29.62 MJ/day (28.08 MBtu/day)
11.41 GJ/year (10.82 MMBtu/year)

3.0 Simulated System Performance Canada
The system referred to in section 1.3 was simulated using WATSUN 12.1 and TMY weather data.

3.1 Simulation Results Canada
Halifax: 2,982 kWh, (10.2 MMBtu)
Ottawa: 3,286 kWh, (11.2 MMBtu)
Victoria: 2,997 kWh, (10.2 MMBtu)

J Solar Thermal Performance USA

1.0 General:
Testing has been performed on both controller and PV based systems. Two PV based systems; SB32-9PV and SB64-9PV, were tested.

2.0 SB64-9 System Test (contoller based system)

2.1 Test Method:
SRCC 200-82, ASHRAE 95-81

2.2 Location:
National Solar Test Facility, Mississauga, Ontario. Date: July 15, 1992.

2.3 Details of System:
Model: SB64-9
Solar Collectors: S32A-P and S32B-P
Collector Area: 5.93 m^2 (63.83 ft^2)
Tank: AO Smith Ken 80 300 L (80 USG)
Aux. Tank: Rheem model 81V52D-B190 L (50 USG)
Heat Exchanger: Shell-and-Coil™
Heat Transfer Fluid: 40% propylene glycol/60% water
Controls: Heliotrope General DTT-84
Pump: Procon 1505 XF

2.4 Test Conditions:
System tested on indoor test bench using solar simulator.

2.5 Collector Tilt:
Normal to incident radiation

2.6 Ambient Temperature:
Tank: 22°C (72°F)
Collectors: 22°C (72°F)

2.7 Windspeed:
Day: 3.5 m/s (11.5 ft/s)
Night: 1.5 m/s (4.9 ft/s)

2.8 Hot Water Load:
42.32 MJ/day @ 50°C - 382.9 L/day (40.11 MBtu/day @ 122°F - 101.2 USG/day)

2.9 Total Daily Solar Radiation:
91.66 MJ (86.88 MBtu)

2.10 Solar Output:
37.41 MJ/day (35.46 MBtu/day)
13.65 GJ/year (12.94 MMBtu/year)

3.0 SB32-9PV and SB64-9PV System Tests (PV based systems)

3.1 Test Method:
SRCC OG-300
SB32-9PV system certification number: 300-92-018E
SB64-9PV system certification number: 300-92-018D

3.2 Location:
Solar Rating and Certification Corporation Technical Support Section, Cape Canaveral, Florida. Date: April 3, 1995.

3.3 Details of System:
Model: SB32-9PV
Solar Collector: S32B-P
Collector Area: 2.97 m^2 (31.96 ft^2)
Tank: 303 L (80 USG) solar storage tank, 189 L (50 USG) SRCC electric auxiliary tank heater.
Heat Exchanger: Shell and Coil™
Heat Transfer Fluid: 50% DOWFROST/ 50% distilled water
Controls: 17 Wp Photovoltaic module with linear current booster
Pump: Procon 1505AF

Model: SB64-9PV
Solar Collector: S32A-P and S32B-P
Collector Area: 5.93 m^2 (63.93 ft^2)
Tank: 303 L (80 USG) solar storage tank, 189 L (50 USG) SRCC electric auxiliary tank heater.
Heat Exchanger: Shell and Coil™
Heat Transfer Fluid: 50% DOWFROST/ 50% distilled water
Controls: 17 Wp Photovoltaic module with linear current booster
Pump: Procon 1505AF

3.4 Test Conditions:
OG-300 thermal performance ratings are determined using mathematical models and correlations in conjunction with the computer simulation program TRNSYS.

3.5 Test Results:
Model SB32-9PV:
Energy Savings/day: 23.7 MJ (22.5 MBtu)
OG-300 Category: C
Solar Energy Factor: 1.6

Model SB64-9PV:
Energy Savings/day: 33.2 MJ (31.5 MBtu)
OG-300 Category: E
Solar Energy Factor: 2.4

4.0 Simulated System Performance USA:
The system referred to in section 1.3 was simulated using WATSUN 12.1 and TMY weather data.

4.1 Simulation Results USA:
Boston: 3,234 kWh, (11.3 MMBtu)
Ft. Worth: 4,931 kWh, (16.8 MMBtu)
Denver: 4,851 kWh, (16.5 MMBtu)
Seattle: 2,873 kWh, (9.8 MMBtu)
San Fran.: 4,667 kWh, (15.9 MMBtu)
Miami: 4,794 kWh, (16.3 MMBtu)
Chicago: 3,586 kWh, (12.2 MMBtu)

The Solar Boiler™ described by this brochure, when properly installed and maintained, meet the minimum standards established by the SRCC (Solar Rating & Certification Corporation). This certification does not imply endorsement or warranty of this product by SRCC.

NATIONAL SOLAR TEST FACILITY