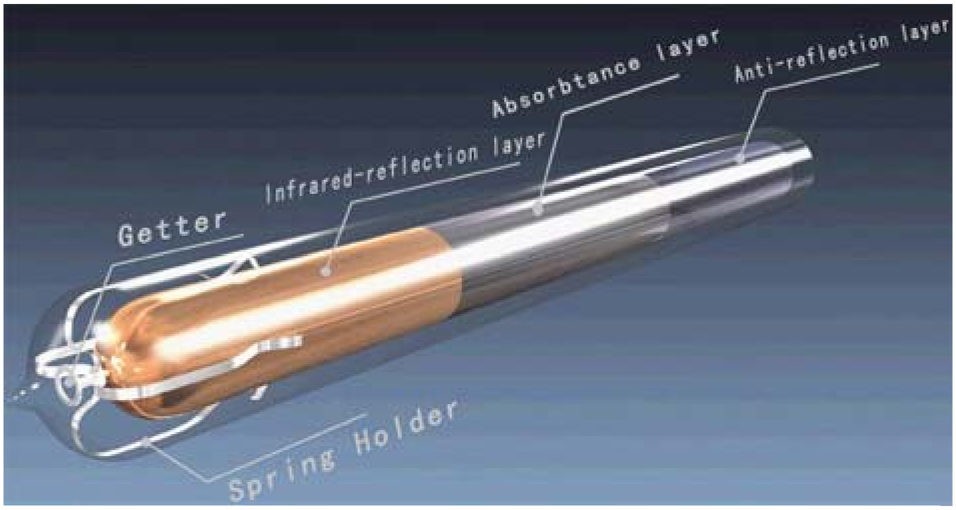
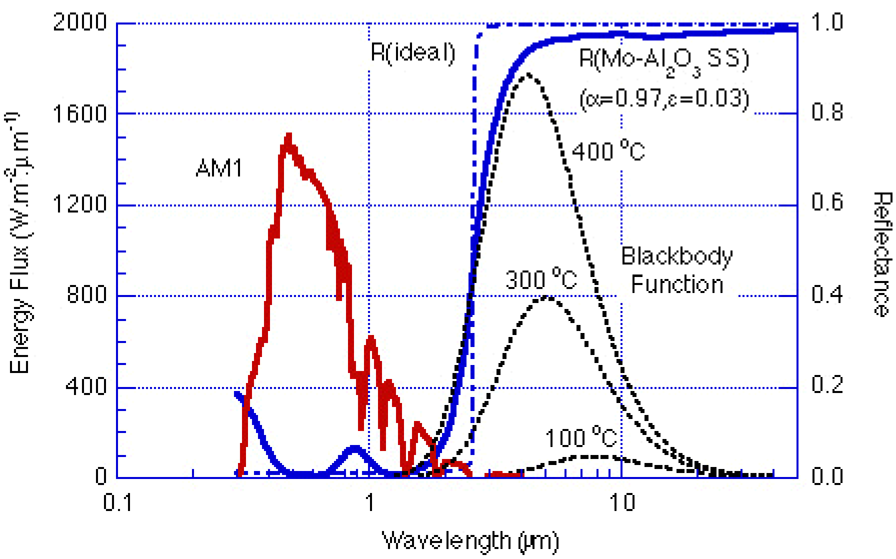




Models	Φ47×150	Φ58×180
Weight	1.35±0.12kg	2.29±0.18kg
Structure	All glass coaxial double-layer tubes	All glass coaxial double-layer tubes
Outer tube diameter	Φ47±0.7mm	Φ58±0.7mm
Inner tube diameter	Φ37±0.7mm	Φ47±0.7mm
Outer Tube thickness	1.6±0.15mm	1.8±0.15mm
Inner tube thickness	1.6±0.15mm	1.6±0.15mm
Tubes length	1542±4mm	1812±4mm
Material of coating	AlN/AIN-SS/Cu	AlN/AIN-SS/CU
Absorptance	0.94~0.96	0.94~0.96
Emittance	0.04~0.06	0.04~0.06
Vacuum	P≤5×10-3pa	P≤5×10-3pa
Transmittance of Outer Tube	0.91	0.91
Stagnation temperature (height)	270~300□	270~300□
Heat-loss coefficient	≤0.6w/ m2*□)	≤0.6 w/ (m2*□)
Bearing hailstone ability	hailstone diameterΦ25mm	hailstone diameterΦ25mm
Pressure-endure ability	1MPa	1MPa

Solar Efficiency

1 Summary

1.1 Preliminary remark to the efficiency measurement

The tests on SPA-58-1800-18-C have been passed according to EN 12975-1,2:2006.
This report is also valid for the collectors SPA-58/1800-20-C, SPA-58/1800-24-C and SPA-58/1800-30-C. The constructive layout of this collectors is identically to the test collector. Only the number of tubes vary. As the collector is constructed without a reflector or another defined reflecting backside, the efficiency measurements were performed by using a tarpaulin with a defined emission coefficient of 83 %. This corresponds to the emission coefficients of common roof tile. All test results were taken from KTB 2006-12 from 15th of August 2006.
This report is a translation to English.

1.2 Boundary conditions for the collector efficiency parameter determination

Test method:	outdoor, steady state
Latitude:	48.0o
Longitude:	7.8o
Collector tilt:	tracked between 40oand 50o
Collector azimuth:	tracked
Mean irradiation :	986 W/m2
Mean wind speed:	3 m/s
Mean flow rate:	124 kg/h
Kind of fluid:	water
Period:	July 2006

1.3 Collector efficiency parameters determined

The calculated parameters rely on following areas:
aperture area of 1.706 m2: absorber area of 1.451 m2:

η0a = 0.573	η0A = 0.674
a1a = 2.085 W/m2K	a1A = 2.452 W/m2K
a2a = 0.0083 W/m2K2	a2A = 0.0098 W/m2K2

Power output per collector unit [W]:

tm-ta [K]	400 [W/m2]	700 [W/m2]	1000 [W/m2]
10	354	647	941
30	272	565	858
50	178	471	764

1.4 Incidence angle modifier - IAM (measured at the outdoor test facility (tracker))

Test method:	outdoor
transversal:	dynamic
longitudinal:	steady state
Latitude:	48.0o
Longitude:	7.8o
Collector tilt:	tracked
Collector azimuth:	tracked

IAM at □:	0o	10o	20o	30o	40o	50o	60o	70o	73o	80o	90o
transversal:	1.00	1.00	1.02	1.10	1.22	1.37	1.42	1.27	1.42	0.93	0.05
longitudinal:	1.00	1.00	1.00	1.00	1.00	0.96	0.91	0.79	0.94	0.53	0.00

Table 1: Measured (bold) and calculated IAM data for SPA-58-1800-18-C

1.5 Effective thermal capacity of the collector

Effective thermal capacity: 25.90 kJ/K
The effective thermal capacity per square meter is: 15.18 kJ/K m2

1.6 Tests on efficiency

Test	Date	Result
Date of delivery:	04.05.2006	
Determination of collector parameters	July 2006	passed

Determination of IAM July 2006 passed
Effective thermal capacity calculated performed

1.7 Summary statement

No problems or distinctive observations occured during the measurements.

2 Test Center

Test Center for Thermal Solar Systems of Fraunhofer ISE
Heidenhofstrae 2, D-79110 Freiburg
Tel.: +49-761-4588-5354 or -5141; Fax.: +49-761-4588-9354
E-mail: arim.schaefer@ise.fraunhofer.de; rommel@ise.fraunhofer.de
Internet: http://www.kollektortest.de

4 Description of the Collector

4.1 Collector

(MS) = Manufacturer Specification

Type:	vacuum tube collector with heat pipe conception
Brand name:	SPA-58-1800-18-C
Serial no.:	1-180-18-0001
Year of production:	2006
Number of test collectors:	1
Collector reference no.:	2 KT 54 002 052006
Total area:	2.100 m * 1.487 m = 3.123 m2 (total dimensions without fittings)
Aperture area:	1.706 m2 (projected area of the inner diameter of the cover tube)
Absorber area:	1.451 m2 (MS) (projected area of outer diameter of absorber tubes)
Material of the cover tube:	Borosilicate glass (MS)
Transmission of the cover tube:	n/a (MS)
Outer diameter of the cover tube:	58 mm (MS)
Thickness of the cover tube:	1.5 mm (MS)
Outer diameter of the inner tube	47 mm (MS)
Thickness of the inner tube:	1.5 mm (MS)
Length of the tubes:	1775 mm (MS)
Distance from tube to tube:	80 mm (MS)
Number of tubes:	18 (MS)
Weight empty:	58 kg (MS)
Volume of the fluid:	1.1 l (MS)
Heat transfer fluid:	antifreeze persistent to high temperatures (MS)

4.2 Absorber	
Material of the absorber:	n/a (MS)
Kind/Brand of selective coating:	sputtered (MS)
Absorptive coefficient :	93% (MS)
Emissivity coefficient ":	> 6.5 % (MS)
Material of the absorber pipes:	copper (MS)
Layout of the absorber pipes:	parallel, heat pipes (MS)
Number of absorber pipes:	18 (MS)
Outer diameter:	8 mm (MS)
Inner diameter:	6.8 mm (MS)
Distance between the pipes:	80 mm (MS)
Material of the header pipe:	copper (MS)
Outer diameter of the header pipe:	22 mm (MS)
Inner diameter of the header pipe:	1 mm (MS)
Material of the contact sheets:	aluminum (MS)
Thickness of the contact sheets:	0.2 mm (MS)
4.3 Insulation and Casing	
Collector dimensions	
Height, width, depth:	2.100 m; 1.487 m; 1.560 m
Medium between the inner and outer tubes of the vacuum flask:	= < 3* 10-2 Pa (MS)
Material of the casing:	high-grade steel (MS)
Sealing material:	silicon (MS)
4.4 Limitations	
Maximum pressure:	800 kPa (MS)
Operating pressure:	6 bar (MS)
Maximum service temperature:	125oC
Maximum stagnation temperature:	250oC
Flow range recommendation:	1.1 l/m2h (MS)
4.5 Kind of mounting	
Flat roof, mounted on the roof:	yes (MS)
Tilted roof, mounted on the roof:	yes (MS)
Tilted roof, integrated:	no (MS)
Free mounting:	yes (MS)
Facade:	yes (MS)

4.6 Picture and cut drawing of the collector

Figure 1: Picture of the collector SPA-58-1800-18-C mounted on the test facility of Fraunhofer ISE

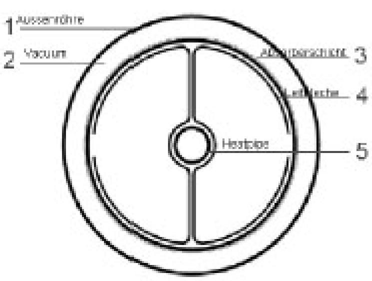


Figure 2: Cut drawing of the vacuum tube KTB Nr.

5 Collector efficiency parameters

5.1 Test method

Outdoor, steady state according to EN 12975-2:2006

Thermal solar systems and components, solar collectors, test methods

5.2 Description of the calculation

The functional dependence of the collector efficiency on the meteorological and system operation values can be represented by the following mathematical equation:

$$\eta_{(G,(t_m-t_a))} = \eta_0 - a_{1a}\frac{t_m - t_a}{G} - a_{2a}\frac{(t_m - t_a)^2}{G} \qquad (1)$$

(based on aperture area)

with: $t_m = \frac{(t_e+t_{in})}{2}$

where: G = global irradiance on the collector area (W/m^2)
t_{in} = collector inlet temperature (°C)
t_e = collector outlet temperture (°C)
t_a = ambient temperature (°C)

The coefficients η_0, a_{1a} und a_{2a} have the following meaning:

η_0: Efficiency without heat losses, which means that the mean collector fluid temperature is equal to the ambient temperature:

$$\frac{(t_{in} + t_e)}{2} = t_a$$

The coefficients a_{1a} and a_{2a} describe the heat loss of the collector. The temperature depedency of the collector heat loss is described by:

$$a_{1a} + a_{2a} * (t_m - t_a)$$

5.3 Instantaneous efficiency parameters based on aperture and absorber area and mean temperature of heat transfer fluid

Boundary conditions:

Test method:	outdoor, steady state
Latitude:	48.0o
Longitude:	7.8o
Collector tilt:	tracked between 40oand 50o
Collector azimuth:	tracked

Test conditions:

Mean irradiation :	986 W/m2
Mean wind speed:	3 m/s
Mean flow rate:	124 kg/h
Kind of fluid:	water

Results:

The calculated parameters rely on following areas1:
aperture area absorber area
(1.706 m2): (1.451 m2):

aperture area ($1.706\ m^2$):		absorber area ($1.451\ m^2$):	
η_{0a}	= 0.573	η_{0A}	= 0.674
a_{1a}	= 2.085 W/m^2K	a_{1A}	= 2.452 W/m^2K
a_{2a}	= 0.0083 W/m^2K^2	a_{2A}	= 0.0098 W/m^2K^2

The determination for the standard deviation (k=2) was performed according ENV 13025 (GUM). Based on this calculation the uncertainty is less than 2%-points of the efficiency values over the complete measured temperature range (η0a = 0.573 +/- 0.02). Based on our experience with the test facilities the uncertainty is much smaller and in a range of +/- 1%-point. The standard deviation of the heat loss parameters resulting from the regression fit curve through the measurements points is:

a1a = 2.085 +/- 0.087 and

a2a = 0.0083 +/- 0.0012 .

1absorber area - projected area of absorber tube,
aperture area - projected area of inner diameter of cover tube

5.4 Power output per collector unit

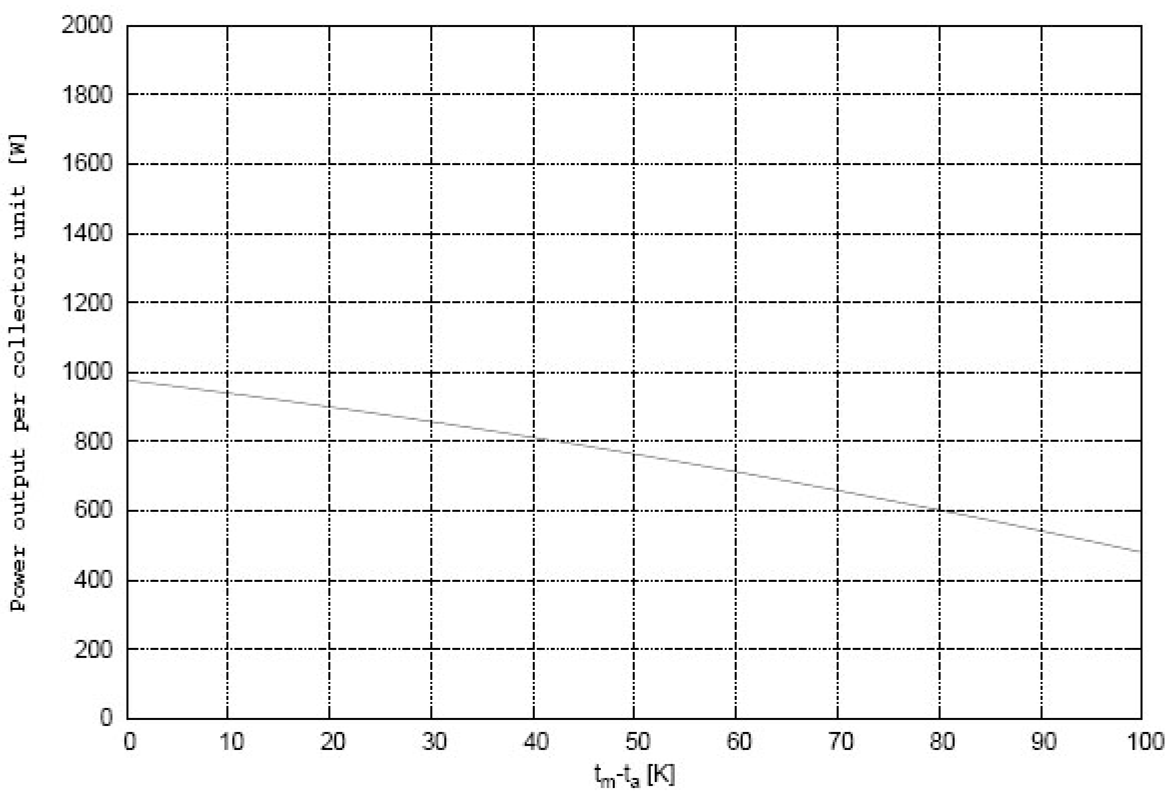


Figure 3: Power output per collector unit based on an irradiance of 1000 W/m^2

Figure 3: Power output per collector unit based on an irradiance of 1000 W/m²

Power output per collector unit [W]:

$t_m - t_a$ [K]	400 [W/m²]	700 [W/m²]	1000 [W/m²]
10	354	647	941
30	272	565	858
50	178	471	764

For more detailed data and the callculated efficiency curve please see annex B.

6 Incidence angle modifier IAM

The Incidence angle modifier IAM is a correction factor representing how the angel of radiation affects the performance of a collector. The IAM is described by a longitudinal and a transversal component.

IAM longitudinal:

The tilt angle of the collector in combination with the zenith angle of the sun results in the incident angle theta (=Θ) in longitudinal direction.

IAM transversal:

The orientation angle of the collector in combination with the azimuth angle of the sun results in the incident angle theta (=Θ) in transversal direction.
The transversal measurement was performed dynamically, what means that the orientation of the tracker was fixed, just the tilt angle was tracked. So the sun is turning around the collector and there is no longitudinal influence (transversal at the present collector means transversal to the ligament of the cover). The incident angle is changing during the day. The resulting values for the incident angle Θ are the mean values between the east and the west measurement.
For the measurement of the IAM longitudinal the orientation and the tilt angle of the tracker were tracked, which means a steady state measurement.

Test method:	outdoor
transversal:	dynamic
longitudinal:	steady state
Latitude:	48.0o
Longitude:	7.8o
Collector tilt:	tracked
Collector azimuth:	tracked

IAM at :	0o	10o	20o	30o	40o	50o	60o	70o	73o	80o	90o
transversal:	1.00	1.00	1.02	1.10	1.22	1.37	1.42	1.27	1.42	0.93	0.05

longitudinal:	1.00	1.00	1.00	1.00	1.00	0.96	0.91	0.79	0.94	0.53	0.00

Table 2: Measured (bold) and calculated IAM data for SPA-58-1800-18-C

The IAM longitudinal was measured for one angle □ = 50. All other angles for the IAM longitudinal in table 2 were calculated according to Ambrosetti 1(equation 2).

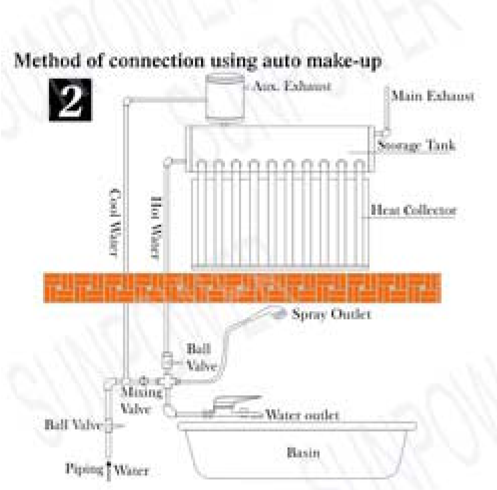
$$K_{\theta} = 1 - [tan\frac{\theta}{2}]^{\frac{1}{r}}$$

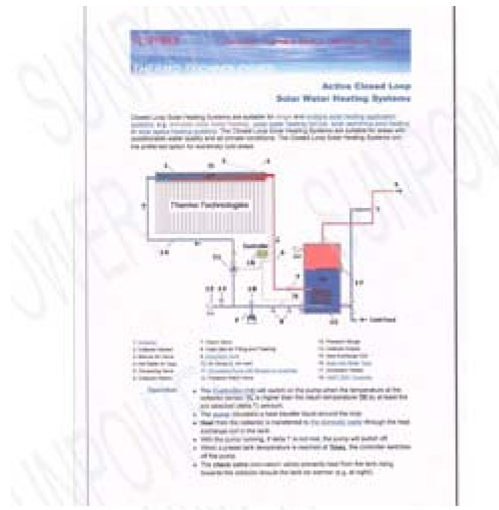
7 Effective thermal capacity of the collector

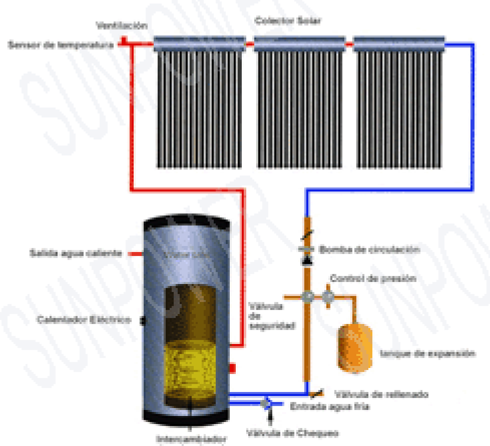
The effective thermal capacity of the collector is calculated according to section 6.1.6.2 of EN 12975-2: 25.90 kJ/K

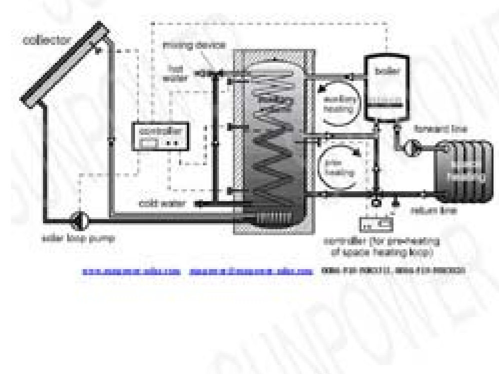
The effective thermal capacity per sqaure meter is: 15.18 kJ/K m2.

Operating Information

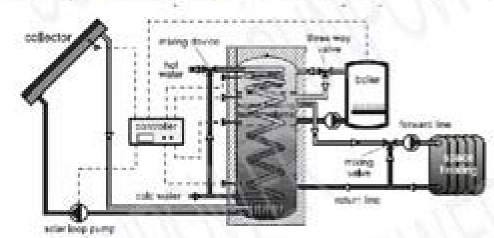




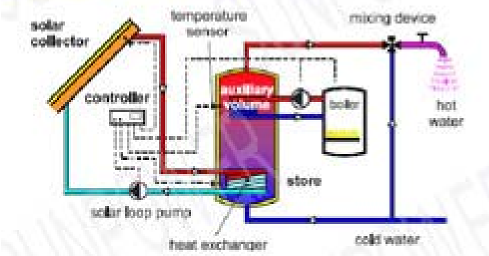




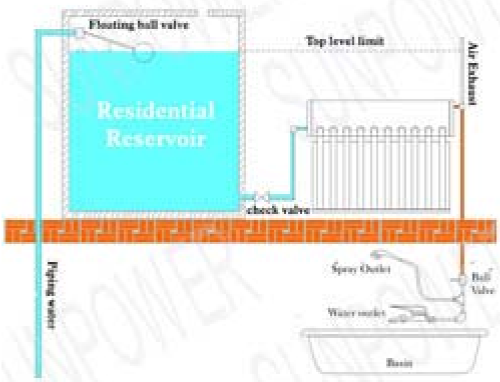
SPACE HEATING AND SOLAR HOT WATER HEATING



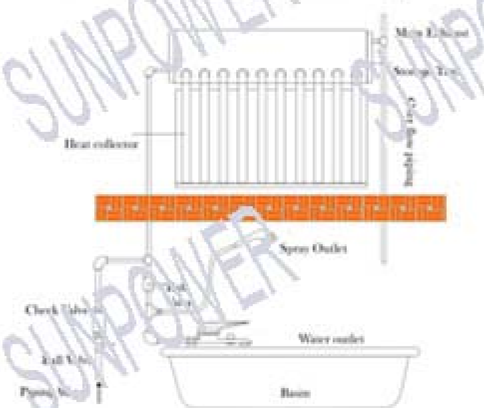
SOLAR HOT WATER HEATING



Method of Connection with residential reservoir



Method of connection for manual make-up



Method of connection using computerized level and temperature control