Institut für Solarenergieforschung GmbH
Hameln / Emmerthal

Centro di prova per componenti
ed impianti solari termici

Am Ohrberg 1 · 31860 Emmerthal · Germany

Rapporto relativo alla verifica delle prestazioni di collettori solari coperti, secondo EN 12975

Deutscher Akkreditierungs Rat
DAP-PL-3662.00

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DEUTSCHES AKKREDITIERUNGSSYSTEM PRÜFWESEN GMBH
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Centro di prova

Indirizzo	Institut für Solarenergieforschung GmbH, Hameln/Emmerthal Am Ohrberg 1 31860 Emmerthal, Germany
Contatto	Dipl.-Ing. C. Lampe Tel.: +49 (0)5151/ 999-522 Fax: -500 E-Mail: Pruefstelle@isfh.de

Base normativa per la prova

Prova secondo	EN 12975-2:2006 Paragrafo 6

Rapporto

Numero	45-08/D
Data	17.04.2008
Numero pagine	2

Committente

Indirizzio	Paradigma s.r.l. Via C. Maffei 3 I- 38080 Darzo (TN), Italia
Referente	Sig. Pellizzari

Collettore in prova

Modello	EasySun II
Costruttore	KBB Kollektorbau GmbH
Modello di serie/prototipo	Modello di serie
Anno di produzione	2007
Numero di serie	00150002

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1. Riepilogo dei risultati della prova

Azienda:	**Paradigma s.r.l.** Via C. Maffei 3 I- 38080 Darzo (TN), Italia	N° rapporto: Data rapporto:	45-08/D 17.04.2008
Modello:	**EasySun II**	Numero di serie: Anno di produzione:	00150002 2007

I risultati qui di seguito menzionati sono stati rilevati nella verifica della potenza termica di collettori solari, secondo EN 12975-2:2006. Essi sono valevoli per il collettore dettagliatamente illustrato nel verbale di rapporto n° 45-08/D, così come per le verifiche e le procedure di rapporto lì descritte.

Dati tecnici del collettore in prova

Tipo di costruzione	Collettore piano selettivo	Superficie captante	1.965 m²
Disegno n°	42002005$0	Superficie assorbitore	1.963 m²
Dimensioni (L/B/H)	1870 / 1150 / 95 mm	Superficie lorda	2.175 m²
Pressione d'esercizio cons.	10 bar	Portata massica cons.	50 kg/m²h
Peso a vuoto	33.5 kg	Spessore lamiera assorbitore	0.5 mm
Fluido termovettore cons.	Acqua e glicole propilenico	Distanza tubi per fluido	110 mm

Risultati della prova

Coefficienti della curva di rendimento
(determinati con simulatore solare in condizioni stazionarie)

$$\eta = \eta_0 - a_1 \cdot (t_m - t_a)/G - a_2 \cdot (t_m - t_a)^2/G$$

Rif.:	superficie captante	Rif.: superficie assorbitore
η_0 =	0.801	0.802
a_1 =	3.65 W/m²K	3.66 W/m²K
a_2 =	0.0169 W/m²K²	0.0169 W/m²K²

Fattori di correzione dell'angolo d'irradiazione
(determinati all'aperto)

$$K_{\theta b}(\theta) = 1 - b_0 \, (1/\cos\theta - 1)$$

$K_\theta(50°)$ = 0.90, for G_d/G = 0.15
b_0 = 0.21
$K_{\theta d}$ = 0.84

Potenza in uscita per unità collettore

$T_m - T_a$	Irradianza 400 W/m²	700 W/m²	1000 W/m²
10 K	555 W	1027 W	1499 W
30 K	384 W	857 W	1329 W
50 K	188 W	660 W	1132 W

Potenza massima per unità collettore **1574 W_{peak}** **a G = 1000 W/m² e $t_m - t_a$ = 0 K**

Perdita di carico (glicole, 20 °C) Δp = 5.6 mbar at $\dot{m}$ = 60.0 kg/h
Δp = 41.0 mbar at $\dot{m}$ =308.5 kg/h

Capacità termica (calculata) c = 5.1 kJ/(m²K) C = 9.9 kJ/K

Temperatura di ristagno t_{stg} = 203 °C a G_S = 1000 W/m² e t_{as} = 30 °C

Emmerthal, 17.04.2008 su incarico

Dipl.-Ing. C. Lampe, Responsabile del centro di prova-EN

Institut für Solarenergieforschung Hameln

Test Centre for Solar Thermal Components and Systems

Am Ohrberg 1 · 31860 Emmerthal · Germany

Report of Performance Test according to EN 12975 for a Glazed Solar Collector

DAP-PL-3662.00

DAP-PL-3662.00

Test Centre

Address	Institut für Solarenergieforschung Hameln Am Ohrberg 1 31860 Emmerthal, Germany
Contact person	Dipl.-Ing. C. Lampe Tel.: +49 (0)5151/ 999-522 Fax: -500 E-Mail: Pruefstelle@isfh.de

Test Basis

Test according to	EN 12975-2:2006 Section 6

Test Report

Number	45-08/D
Date	17.04.2008
Number of pages	21

Customer

Address	Paradigma s.r.l. Via C. Maffei 3 I- 38080 Darzo (TN), Italy
Contact person	Mr. Pellizzari

Test Collector

Type	EasySun II
Manufacturer	KBB Kollektorbau GmbH
Serial- or Prototype	Serial type
Year of production	2007
Serial number	00150006

Contents

Institut für Solarenergieforschung Hameln

Test Centre for Solar Thermal Components and Systems

Am Ohrberg 1 · 31860 Emmerthal · Germany

1. Summary of the Results

Company:	**Paradigma s.r.l.** Via C. Maffei 3 I- 38080 Darzo (TN), Italy	Report no.: Report date:	45-08/D 17.04.2008
Type:	**EasySun II**	Serial no.: Year of production:	00150006 2007

The following results were obtained from a test of the thermal performance of a solar collector according to **EN 12975-2:2006**. They apply to the collector described more precisely in the test report no. 45-08/D and to the tests and procedures described herein.

Description of the collector

Type	flat plate collector	Aperture area	1.965 m²
Drawing no.	42002005$0	Absorber area	1.963 m²
Length/Width/Height	1870 / 1150 / 95 mm	Gross area	2.175 m²
Max. operation pressure	10 bar	Recommended flow rate	50 kg/m²h
Weight, empty	33.5 kg	Thickness of absorber sheet	0.5 mm
Heat transfer fluid	water/propylene glycol	Tube distance	110 mm

Test results

Coefficients of efficiency
(determined in the sun simulator SUSI I under steady state conditions)

$$\eta = \eta_0 - a_1 \cdot (t_m - t_a)/G - a_2 \cdot (t_m - t_a)^2/G$$

Based on:	aperture area	absorber area
η_0 =	0.801	0.802
a_1 =	3.65 W/m²K	3.66 W/m²K
a_2 =	0.0169 W/m²K²	0.0169 W/m²K²

Incident angle modifier
(determined outdoor)

$$K_{\theta b}(\theta) = 1 - b_0\,(1/\cos\theta - 1)$$

$K_\theta(50°)$ =	0.90, for G_d/G = 0.15
b_0 =	0.21
$K_{\theta d}$ =	0.84

Power output per collector unit

	Irradiance		
$T_m - T_a$	400 W/m²	700 W/m²	1000 W/m²
10 K	555 W	1027 W	1499 W
30 K	384 W	857 W	1329 W
50 K	188 W	660 W	1132 W

Peak power output per collector unit **1574 W_{peak}** **at G = 1000 W/m² and t_m-t_a = 0 K**

Pressure drop (water, 20 °C) Δp = 5.6 mbar at ṁ = 60.0 kg/h; Δp = 41.0 mbar at ṁ = 308.5 kg/h

Thermal capacity (calculated) c = 5.1 kJ/(m²K) C = 9.9 kJ/K

Stagnation temperature t_{stg} = 203 °C at G_S = 1000 W/m² and t_{as} = 30 °C

Emmerthal, 17.04.2008 pp

Dipl.-Ing. C. Lampe, Head of Test Centre-EN

2. Description of the Collector

2.1. Collector

Manufacturer	KBB Kollektorbau GmbH Bruno-Bürgel-Weg 142-144, D- 12439 Berlin
Type	EasySun II
Construction	flat plate collector, Serial type
Year of production	2007
Serial number	00150006
Weight, empty, without glazing	18.6 kg (according to manufacturer)
Weight, empty, with glazing	33.5 kg (weighed at ISFH)

2.2. Glazing

Number of glazings	one
Dimensions	1844 mm 1125 mm x 3.2 mm
Material	safety glass, low iron; with structure, manufacturer: AFG, type Solartex
Aperture area	1.808 m x 1.087 m = 1.965 m²
Solar transmittance	τ = 91.5% (according to manufacturer)

2.3. Absorber

Absorber material	aluminium plate, thickness 0.5 mm (according to manufacturer)
Material of fluid tubes	copper, d_i /d_a= 7.2 / 8 mm
Connection between absorber and tubes	laser welding
Hydraulic construction	two series-connected groups of 5 parallel tubes, tube distance approx. 110 mm
Absorber layer	selective (BlueTec, type eta plus-Al)
Solar absorptance	α = 94±2 % (according to manufacturer)
Hemispherical emittance	ε = 5 ± 2 % (according to manufacturer)
Absorber dimensions	1.825 x 1.100 m² = 2.008 m² (according to manufacturer)

2.4. Heat Transfer Fluid

Specifications	water/propylene glycol
Alternative acceptable heat transfer fluids	no details
Fluid content	1.16 l (weighed at ISFH)

2.5. Casing

Dimensions (L / W / H)	1870 / 1150 / 95 mm
Material of frame	aluminium profiles
Material of back plate	aluminium sheet
Sealing material between the frame segments	Silicone

Sealing material between the frame and the glazing	Silicone

2.6. Insulation

Insulation construction	plate
Insulation material	mineral wool
Thickness	50 mm

2.7. Reference Areas

Absorber area	1.963 m² (partially limited by the aperture area)
Aperture area	1.965 m²
Gross area	2.175 m²

2.8. Collector Mounting

Collector tilt angle	20°..90°
On sloped roof	yes
Integrated into sloped roof	yes
On flat roof	no
On flat roof with stand	yes
Facade	yes

2.9. Limitations

Stagnation temperature	placeholder, determination in section 9 of this report
Maximum pressure	10 bar

3. Validity

1. This test report is valid for the collector (description see section 2) with the serial number 00150006.

3.1. Tests carried over

The tests were carried out at the collector type K420-DH of the company KBB Kollektorbau GmbH (test report no. 86-07/D) which is identical in construction compared to the collector type EasySun II. With this report the test results are carried over to the collector type EasySun II of the company Paradigma s.r.l..

4. Photograph of the Collector

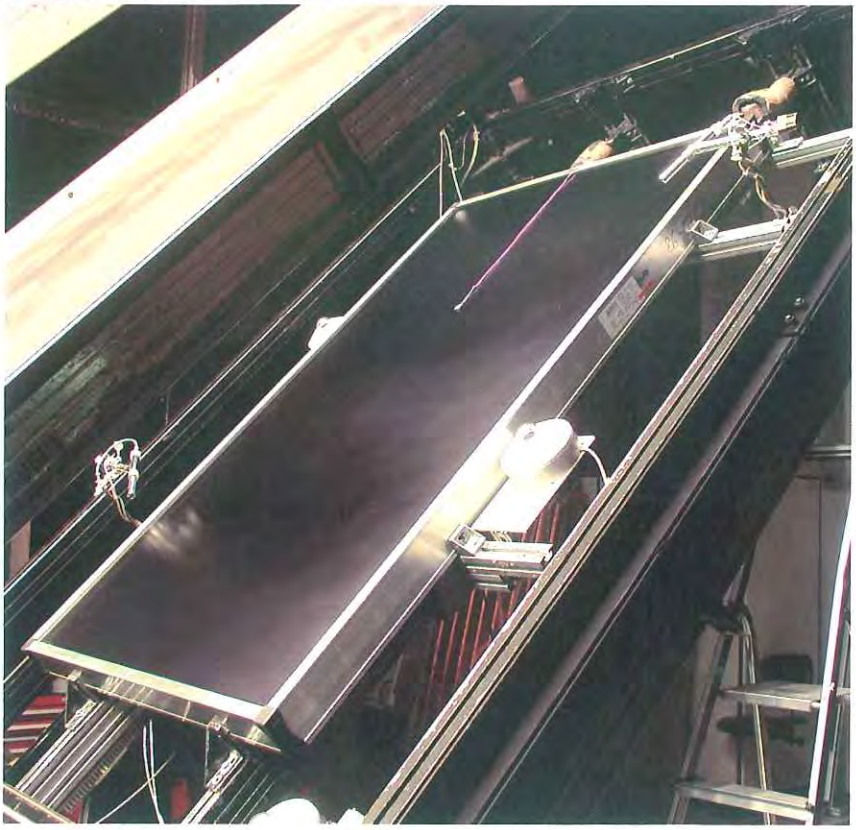

Fig. 4-1: Picture of the collector, mounted in the sun simulator SUSI I

5. Sampling

Date of sampling:	25.07.2007
Place of sampling:	Factory stock of the company KBB Kollektorbau GmbH, Bruno-Bürgel-Weg 142-144, D- 12439 Berlin
Inspector:	Carsten Lampe (employee of the Test Centre)

Description of sampling:

The collector with the serial number 00150006 was chosen out of 8 identical products. The collector was marked in the store ("ISFH-TEST"Label number 02261) and on the 27.07.2007 delivered to the test centre. The manufacturer has proved through his factory production control and his quality management system conformity of the test sample with the series production.

6. Documents; Collector Identification

Drawings:	The following drawings were presented by the customer * 42002005$0 * 18041601$0
Collector data sheet:	A data sheet with details about the tested collector was presented by the customer.
Labelling of the collector:	The test collector has a visible and durable type label.
Installer instruction manual:	The following documents were presented by the customer: * Installation instruction for mounting (Date: 2007) * Installations instructions (Date: 12/2007) * Technical data sheet (Date: 12/2007)

7. Installation of Sensors

The collector was equipped with three temperature sensors (Pt 100, class A), as described in the following. These sensors measure the temperatures of the glass cover, of the collector back and the absorber temperature. Care was taken that the sensors do not influence the results of the following tests. The temperatures measured are given in table A-2 in the appendix.

Name of the sensor	Position
t_{sm}	Absorber temperature sensor, at 2/3 of the height of the absorber, between the third and the forth absorber tube from the left (as seen from the front side)
t_{glas}	Glass temperature sensor, at 2/3 of the height of the glass pane
t_{back}	Backside temperature sensor (exactly beneath glass temperature sensor)

8. Exposure to Irradiation

The collector was exposed to irradiation before the performance test.

Tab. 8-1: Test conditions during the exposure

Date: 08.08.2007 Test facility: SUSI I (indoor test with sun simulator) Inspector: Gerd Schiewe (employee of the test centre)		
	Conditions stipulated in EN 12975-2	Test conditions
Collector tilt angle	-	45 °
Solar irradiance	> 700 W/m²	781 W/m²
Ambient temperature, mean value	-	29.1 °C
Duration of exposure	> 5 h	5 h
Result: The collector showed no changes during and after the exposure test.		

9. Determination of the Stagnation Temperature

During the exposure to irradiation (see section 8), the stagnation temperature of the collector was determined.

9.1. Mathematical Procedure[a]

$$t_{stg} = a \cdot G_s^{\frac{1}{1.3}} + t_{as} \qquad \text{eqn. (9.1)}$$

t_{stg} = stagnation temperature under standard conditions in °C
G_s = standard global irradiance
t_{as} = standard ambient temperature

a. For the calculation of the stagnation temperature under standard conditions, the eqns. (9.1) and (9.2) are used, as this method has a lower uncertainty than the procedure described in EN 12975-2.

$$a = \frac{(t_{sm} - t_{am})}{G_m^{1/1.3}} \qquad \text{eqn. (9.2)}$$

t_{sm} = measured absorber temperature in °C

t_{am} = measured ambient temperature in °C

G_m = measured global irradiance (in the collector plane) in W/m²

9.2. Test Conditions and Results

Date:	08.08.2007		
Test facility:	SUSI I (indoor test with sun simulator)		
Inspector:	Gerd Schiewe (employee of the test centre)		
Collector tilt angle:	45°		
	Test conditions	Standard conditions according to ISO 9806-2	
		Class A (temperate), corresponding to conditions stipulated in EN 12975-2	Class B (sunny)
Global irradiance	823 W/m²	1000 W/m²	1100 W/m²
Surrounding air speed	< 1 m/s	< 1 m/s	< 1 m/s
Ambient temperature	29.3 °C	30 °C	40 °C
Measured absorber temperature (t_{sm})	177.8 °C		
Calculated stagnation temperature (t_{stg})		**203 °C**	226 °C

10. Instantaneous Collector Efficiency

10.1. Test Procedure

Thermal performance testing under steady state conditions by using a solar irradiance simulator (see EN 12975-2, section 6.1.5).

10.2. Indications for the Sun Simulator

The sun simulator in use adheres to the requirements given in EN 12975-2, section 6.1.5.2. To evaluate the quality of indoor measurement, the value of conversion factor η_0 measured by using the sun simulator was compared to that from outdoor measurement (determined simultaneously to the incidence angle modifier, see section 11). As a result, the values from indoor measurements were slightly corrected. The conversion factor η_0 given in this report corresponds to a value that would be measured outdoor at a ratio of diffuse to global radiation of $G_d/G = 0.15$.

10.3. Mathematical Description

$$\eta = \eta_0 - a_1 \cdot \frac{t_m - t_a}{G} - a_2 \cdot \frac{(t_m - t_a)^2}{G} \qquad \text{eqn. (10.1)}$$

η	= efficiency
η_0	= efficiency for $t_m - t_a = 0$ (conversion factor)
a_1	= heat loss coefficient, independent of temperature, in W/m²K
a_2	= heat loss coefficient, depending on temperature, in W/m²K²
G	= global irradiance in W/m²
t_m	= mean fluid temperature in the collector in °C, $t_m := (t_{in} + t_e)/2$
t_{in}	= collector inlet temperature in °C
t_e	= collector outlet temperature in °C
t_a	= ambient temperature in °C
T_m^*	= reduced temperature difference, in m²K/W

10.4. Test Conditions and Results

The test conditions are shown in table 10-1. All measured data are given in table A-1 and table A-2 in the appendix.

Tab. 10-1: Test conditions of the efficiency measurements in the sun simulator

Date:	09.08.2007 and 10.08.2007
Test facility:	SUSI I (indoor test with sun simulator)
Inspector:	Gerd Schiewe (employee of the test centre)
Lamps used:	halogen lamps, Philips type 13117
Heat transfer fluid:	water

	Conditions stipulated in EN 12975-2	Test conditions
Collector tilt angle	-	45°
Mean global irradiance	> 700 W/m²	804 W/m²
Mean thermal irradiance[1)]	≤ 494 W/m²	443 W/m²
Mean ambient temperature	-	25.9 °C
Mean air speed over the collector	3 m/s ± 1 m/s	3.4 m/s
Mass flow rate of the heat transfer fluid	0.02 kg/(m²s) or according to manufacturer	300 kg/h

1) For protection against long wave radiation there is an air cooled channel, made of two acrylic glass panes, between the lamps and the collector. The thermal irradiance is determined from a measurement of the surface temperature of the lower acrylic glass pane.

Tab. 10-2: Coefficients of the efficiency curve, related to different areas

Related to area:	η_0	a_1	a_2
Aperture area (1.965 m²)	**0.801**	**3.65 W/m²K**	**0.0169 W/m²K²**
Absorber area (1.963 m² (partially limited by the aperture area))	0.802	3.66 W/m²K	0.0169 W/m²K²
Gross area (2.175 m²)	0.724	3.30 W/m²K	0.0153 W/m²K²
Standard deviation (related to the aperture area)	0.0045	0.103 W/m²K	-[1)]

1) a_2 is assumed to be constant and faultless because a_1 and a_2 are strongly correlated. Thats is why the whole uncertainty of the heat loss coefficients is accredited to a_1.

Note:

If the parameters are given in the documents of the collector, the area to which they are related must be mentioned.

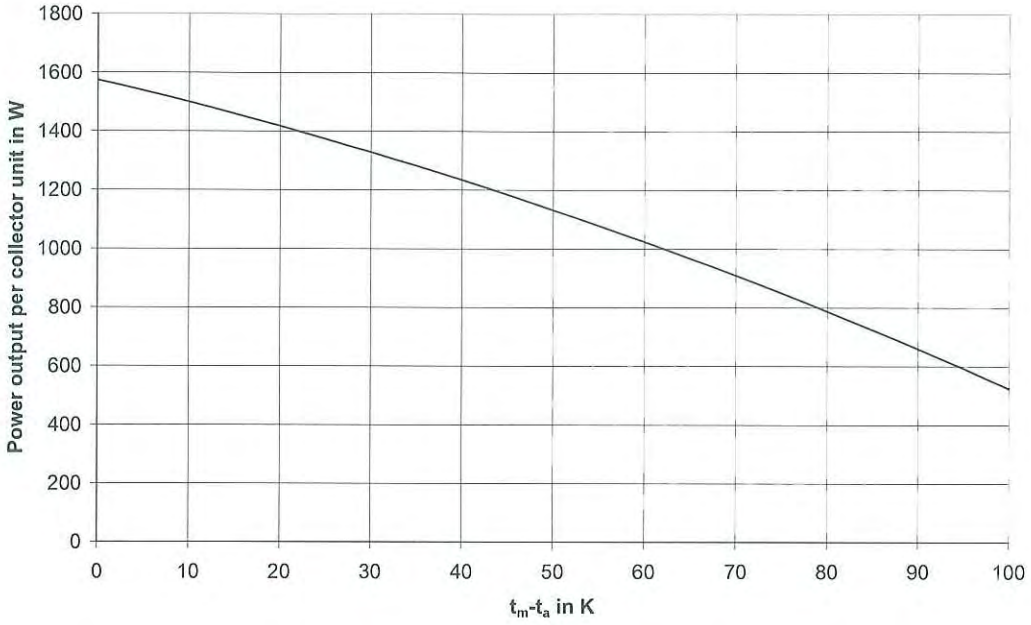

Fig. 10-1: Power curve for G = 1000 W/m², related to the collector unit

11. Incident Angle Modifier of the Collector

11.1. Test Procedure

The incident angle modifier is measured outdoor under quasi-dynamic test conditions (see chapter 6.3.4.6.4 a) of EN 12975-2). During the measurement the mean fluid temperature of the collector is close to the ambient temperature (low deviations are corrected by the heat loss coefficients given in section 10). The variation of the incident angle is achieved by the sun's path over the collector.

11.2. Mathematical Description

The determination of the incident angle modifier is based on the division of the natural solar irradiance into a diffuse part (G_d) and a direct part (G_b). In accordance with EN 12975-2 (chapter 6.3.4.8.2) the efficiency can be calculated with the following equation (for the sake of simplification, it is assumed that the mean fluid temperature and the ambient temperature are equal).

$$\eta_0 \cdot G = F'(\tau\alpha)_{en} \cdot G \cdot \left(K_{\theta b}(\theta) \cdot \left(1 - \frac{G_d}{G}\right) + K_{\theta d} \cdot \frac{G_d}{G}\right) - \left(c \cdot \frac{dt_m}{dt}\right) \qquad \text{eqn. (11.1)}$$

η_0 = efficiency for $t_m - t_a = 0$ (conversion factor)
G = global irradiance in W/m²
$F'(\tau\alpha)_{en}$ = conversion factor for pure beam radiation at normal incidence
$K_{\theta b}(\theta)$ = incident angle modifier for beam radiation as a function of the incident angle θ
$K_{\theta d}$ = incident angle modifier for diffuse radiation
G_d = diffuse irradiance in W/m²
c = effective heat capacity of the collector in J/m²K
t_m = mean temperature of heat transfer fluid in °C

$$K_{\theta b}(\theta) = \frac{F'(\tau\alpha)_{en}(\theta)}{F'(\tau\alpha)_{en}} \qquad \text{eqn. (11.2)}$$

$F'(\tau\alpha)_{en}(\theta)$ = conversion factor for pure beam radiation as a function of the incident angle θ

The incident angle modifier for beam radiation ($K_{\theta b}$) as a function of the incident angle is described by the following equation (see chapter 6.3.6 of EN 12975-2)

$$K_{\theta b}(\theta) = 1 - b_0 \cdot \left(\frac{1}{\cos\theta} - 1\right) \qquad \text{eqn. (11.3)}$$

b_0 = coefficient characterizing the incident angle modifier for beam radiation

Effective incident angle modifiers for global radiation can be calculated with the following equation.

$$K_\theta(\theta) = \frac{K_{\theta b}(\theta) \cdot 0.85 + K_{\theta d} \cdot 0.15}{0.85 + K_{\theta d} \cdot 0.15} \qquad \text{eqn. (11.4)}$$

$K_\theta(\theta)$ = incident angle modifier for $G_d/G = 0.15$
$K_{\theta d}$ = incident angle modifier for diffuse radiation

11.3. Test Conditions and Results

Tab. 11-1: Test conditions during the measurement of the incident angle modifier

Date:	23.08.2007 until 05.09.2007	
Test facility:	Test roof 1	
Inspector:	Carsten Lampe (employee of the Test Centre)	
Heat transfer fluid:	water	
	Conditions stipulated in EN 12975-2	Test conditions
Collector tilt angle	-	45°
Collector azimuth angle	-	0° (south)
Mass flow rate $\dot{m}$	0.02 kg/(m²s) or according to manufacturer	341 kg/h
Latitude	-	52.1° N
Longitude	-	9.4° E
Local time (MEZ) at solar noon	-	12:20

Tab. 11-2: Coefficients of the incident angle modifier

$K_\theta(50°)$	b_0	$K_{\theta d}$
0.90, for Gd/G = 0.15	0.21	0.84

12. Thermal Capacity of the Collector

The thermal capacity of the collector is calculated according to EN 12975-2, as the sum of the capacities of its constituent elements, taking into account weighting factors. These weighting factors evaluate that some elements are only partially involved in the thermal inertia of the collector.

$$C = \sum p_i \cdot m_i \cdot c_i \qquad \text{eqn. (12.1)}$$

C = effective thermal capacity of the collector in kJ/K

p_i = weighting factor of the component (according to tabular 6 in EN 12975-2:2006, chapter 6.1.6.2)

m_i = Mass of the component in kg

c_i = specific thermal capacity of the component kJ/(kgK)

12.1. Result

Date: 02.10.2007 Inspector: Nele Rumler (employee of the test centre)	
	calculated according to EN 12975-2:
effective thermal capacity	9.9 kJ/K
specific thermal capacity related to the aperture area	5.1 kJ/(m²K)

13. Pressure Drop across the Collector

13.1. Test Procedure

The pressure drop is measured at different mass flow rates according to EN 12975-2, chapter 6.1.8.

13.2. Test Conditions and Results

Tab. 13-1: Results of the pressure drop measurements

Date:	12.10.2007
Test facility:	Δp-test facility with U-tube differential pressure gauge
Inspector:	Gerd Schiewe (employee of the test centre)
Heat transfer Fluid:	water-glycol mixture
Fluid temperature:	20 ± 2°C

Mass flow rate in kg/h	60.0	164.1	308.5	495.8	723.7
Pressure drop in mbar	5.6	18.9	41.0	77.6	135.2

Compared to the measurement using water, the pressure drop is markedly higher when using a water-glycol mixture as heat transfer fluid, because its viscosity is much higher.

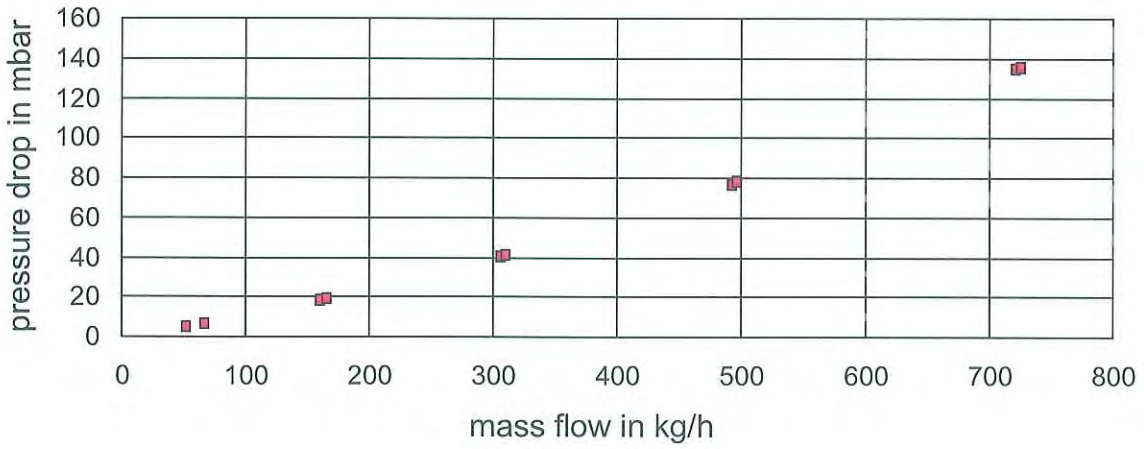

Fig. 13-1: Measured pressure drop of the collector (heat transfer fluid: water-glycol mixture)

14. Observations; Status of the Collector

Status of the collector after

- delivery: faultless
- exposure to irradiation: no change (no severe problems)
- performance test: no change (no severe problems)
- end of tests: no change (no severe problems)

There were no extraordinary incidents during the tests.

No sharp edges, loose fixing elements or other characteristics representing a possible endangering were observed.

15. Stipulations from the Test Centre

1. This test report is valid for the collector (description see section 2) with the serial number 00150006.
2. Prior to passing on to others or reproducing parts of this test report, permission must be obtained. Passing on the single pages 3, 20, 21 or the coherent pages 1 to 17 or the complete test report is generally approved.

Test Centre for Solar Thermal
Components and Systems

pp

Dipl.-Ing. C. Lampe

Head of Test Centre-EN

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Table A-1: Measured and Calculated Data from the Efficiency Tests, Related to the Aperture Area

No.	G	$\dot{m}$	t_{in}	t_e	$t_e - t_{in}$	t_m	t_a	$t_m - t_a$	T^*_m	η_a
-	W/m²	kg/h	°C	°C	K	°C	°C	K	Km²/W	-
1	804.7	300.0	24.1	27.7	3.6	25.9	25.9	0.0	0.0000	0.801
2	803.9	300.0	24.0	27.6	3.6	25.8	25.9	-0.1	-0.0001	0.801
3	804.2	300.3	40.9	44.2	3.3	42.5	25.9	16.7	0.0207	0.719
4	802.9	300.5	40.9	44.1	3.3	42.5	25.9	16.7	0.0207	0.719
5	800.7	299.6	60.9	63.6	2.7	62.3	26.1	36.1	0.0451	0.606
6	801.6	299.8	60.9	63.6	2.7	62.2	26.1	36.2	0.0451	0.605
7	802.2	300.1	80.9	83.0	2.2	81.9	26.0	55.9	0.0697	0.481
8	802.2	300.3	80.9	83.0	2.2	81.9	26.0	55.9	0.0697	0.481
9	802.0	300.2	80.9	83.1	2.2	82.0	26.0	56.0	0.0698	0.480
10	800.9	300.2	80.9	83.0	2.2	82.0	26.0	56.0	0.0699	0.480
11	802.7	299.8	60.9	63.7	2.7	62.3	25.8	36.5	0.0455	0.607
12	802.4	299.8	60.9	63.7	2.7	62.3	25.8	36.5	0.0455	0.607
13	807.6	300.4	41.3	44.6	3.3	43.0	25.6	17.4	0.0215	0.719
14	807.8	300.5	41.3	44.5	3.3	42.9	25.7	17.2	0.0213	0.719
15	805.1	299.6	23.9	27.6	3.6	25.8	25.9	-0.1	-0.0001	0.801
16	805.1	299.6	23.9	27.6	3.6	25.8	25.9	-0.1	-0.0001	0.800

Nomenclature:

G	W/m²	hemispherical (= global) solar irradiance in the collector plane
$\dot{m}$	kg/h	mass flow rate of the heat transfer fluid
t_{in}, t_e	°C	collector inlet temperature and collector outlet (exit) temperature
t_m	°C	mean temperature of heat transfer fluid, t_m: = $(t_{in} + t_e)/2$
t_a	°C	ambient temperature
T^*_m	(m²K)/W	reduced temperature difference, $T^*_m = (t_m - t_a)/G$
η_a	-	collector thermal efficiency, related to the aperture area

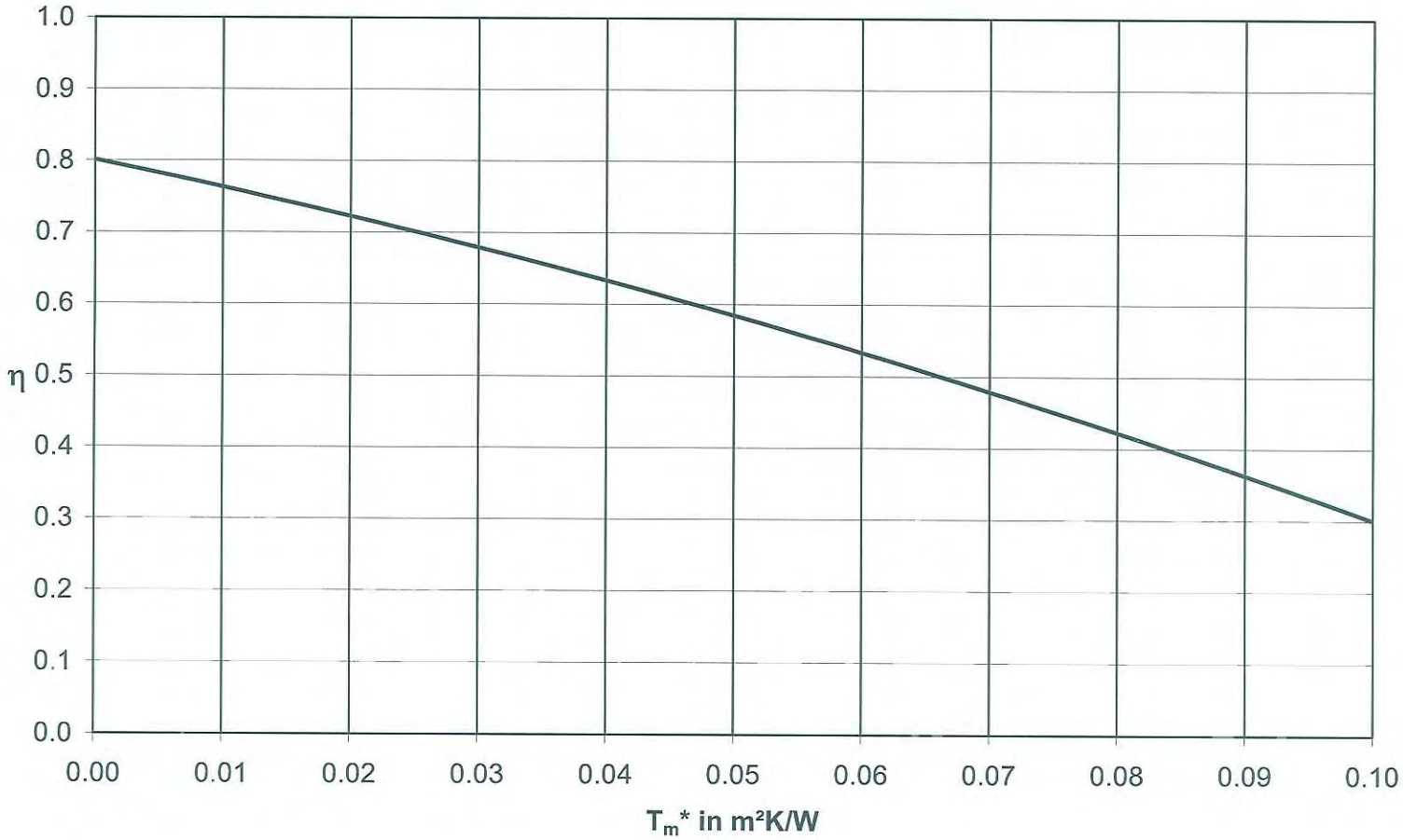
Table A-2: Temperatures at Different Positions of the Collector, Meteorological Quantities

No.	t_{in}	t_e	t_m	t_a	t_s	t_{glas}	t_{back}	t_{sm}	u
-	°C	°C	°C	°C	°C	°C	°C	°C	m/s
1	24.1	27.7	25.9	25.9	24.0	36.3	28.4	25.4	3.4
2	24.0	27.6	25.8	25.9	24.0	36.3	28.5	25.5	3.4
3	40.9	44.2	42.5	25.9	23.9	51.5	30.7	26.1	3.4
4	40.9	44.1	42.5	25.9	24.0	51.5	30.6	26.0	3.4
5	60.9	63.6	62.3	26.1	24.5	69.7	34.1	26.7	3.4
6	60.9	63.6	62.2	26.1	24.5	69.7	34.1	26.7	3.4
7	80.9	83.0	81.9	26.0	24.3	88.0	37.5	27.1	3.4
8	80.9	83.0	81.9	26.0	24.3	88.0	37.4	27.2	3.4
9	80.9	83.1	82.0	26.0	24.2	88.0	37.3	27.1	3.4
10	80.9	83.0	82.0	26.0	24.1	88.0	37.4	27.1	3.4
11	60.9	63.7	62.3	25.8	23.8	69.8	33.8	26.5	3.4
12	60.9	63.7	62.3	25.8	23.8	69.8	33.8	26.5	3.4
13	41.3	44.6	43.0	25.6	24.5	52.0	30.6	25.7	3.4
14	41.3	44.5	42.9	25.7	24.5	51.9	30.7	25.7	3.4
15	23.9	27.6	25.8	25.9	24.2	36.2	28.5	25.4	3.4
16	23.9	27.6	25.8	25.9	24.2	36.2	28.5	25.4	3.4

Nomenclature:

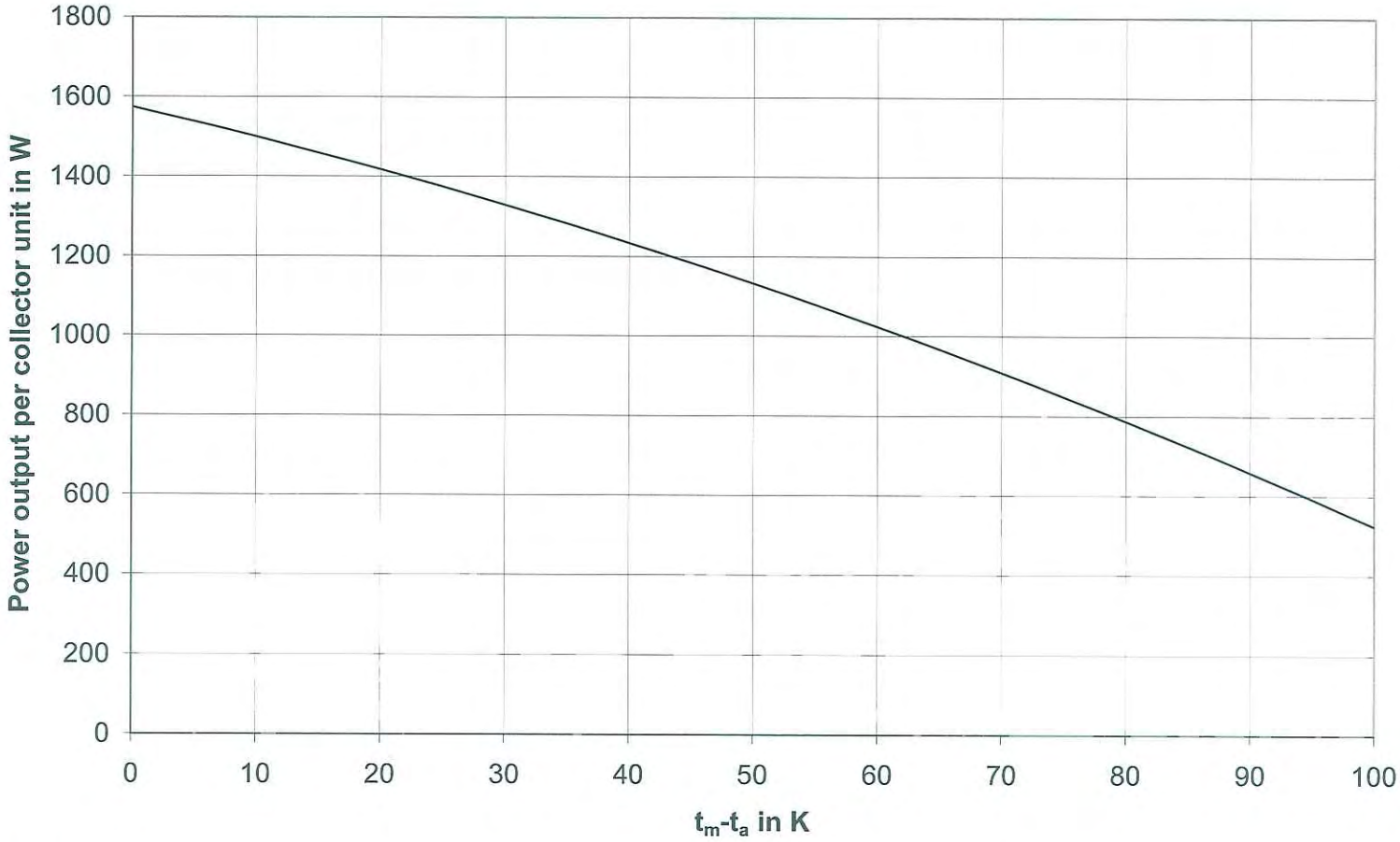
t_{in}, t_e	°C	collector inlet temperature and collector outlet (exit) temperature
t_m	°C	mean temperature of heat transfer fluid, t_m: = $(t_{in} + t_e)/2$
t_a	°C	ambient temperature
t_s	°C	sky temperature
t_{glas}	°C	temperature of the transparent cover
t_{back}	°C	temperature of the backside of the collector
t_{sm}	°C	absorber temperature
u	m/s	surrounding air speed

Collector Efficiency Curve for G = 800 W/m², Related to the Aperture Area



Company:	Paradigma s.r.l.	Solar collector test	Report date: 17.04.2008
Collector type:	EasySun II	according to EN 12975-2:2001	Report no.: 45-08/D
Serial No.:	00150006		Page 20 of 21
Aperture area:	1.965 m²		

Power Curve for G = 1000 W/m², Related to the Collector Unit



Company:	Paradigma s.r.l.	Solar collector test	Report date: 17.04.2008
Collector type:	EasySun II	according to EN 12975-2:2001	Report no.: 45-08/D
Serial No.:	00150006		Page 21 of 21
Gross area:	2.175 m²		

Institut für Solarenergieforschung Hameln

Test Centre for Solar Thermal Components and Systems

Am Ohrberg 1 · 31860 Emmerthal · Germany

Report of Reliability Test according to EN 12975 for a Glazed Solar Collector

DAP-PL-3662.00

DEUTSCHES AKKREDITIERUNGSSYSTEM PRÜFWESEN GMBH
DAP-PL-3662.00

Test Centre

Address	Institut für Solarenergieforschung Hameln Am Ohrberg 1 31860 Emmerthal, Germany
Contact person	Dipl.-Ing. C. Lampe Tel.: +49 (0)5151/ 999-522; Fax: -500 E-Mail: Pruefstelle@isfh.de

Test Basis

Test according to	EN 12975-2:2006 Section 5

Test Report

Number	46-08/Q
Date	17.04.2008
Number of pages	19

Customer

Address	Paradigma s.r.l. Via C. Maffei 3 I- 38080 Darzo (TN) Italy
Contact person	Mr. Pellizzari

Test Collector

Type	EasySun II
Manufacturer	KBB Kollektorbau GmbH
Serial- or Prototype	Serial type
Year of production	2007
Serial number	00150002

Contents

Appendix:

Institut für Solarenergieforschung Hameln

Test Centre for Solar Thermal Components and Systems

Am Ohrberg 1 · 31860 Emmerthal · Germany

1. Summary of the Results

Company:	**Paradigma s.r.l.** Via C. Maffei 3 I- 38080 Darzo (TN), Italy	Report no.: Report date:	46-08/Q 17.04.2008
Type:	**EasySun II**	Serial no.: Year of production:	00150002 2007

The following results were obtained from a test of the reliability of a solar collector according to EN 12975-2:2006. They apply to the collector described more precisely in the test report no. 46-08/Q and to the tests and procedures described herein.

Description of the collector

Type	flat plate collector	Aperture area	1.965 m²
Drawing no.	42002005$0	Absorber area	1.963 m²
Length/Width/Height	1870 / 1150 / 95 mm	Gross area	2.175 m²
Max. operation pressure	10 bar	Recommended flow rate	50 kg/m²h
Weight, empty	33.5 kg	Thickness of absorber sheet	0.5 mm
Heat transfer fluid	water/propylene glycol	Tube distance	110 mm

Test Results

☑ no problem ◎ minor problem ☐ severe problem

Test		Date start	Date end	Result	
Check of documents		20.12.2007	20.12.2007	complete	
Internal pressure test	1st test	01.08.2007	01.08.2007	no problem	☑
	2nd test	15.10.2007	15.10.2007	no problem	☑
Exposure test		01.08.2007	15.10.2007	no problem	☑
High-temperature resistance test		23.08.2007	23.08.2007	no problem	☑
Determination of the stagnation temperature		08.08.2007	08.08.2007	t_{stg} = 203 °C (at G_S = 1000 W/m² and t_{as} = 30 °C)	
Internal thermal shock test	1st test	06.08.2007	06.08.2007	no problem	☑
	2nd test	24.09.2007	24.09.2007	no problem	☑
External thermal shock test	1st test	14.08.2007	14.08.2007	no problem	☑
	2nd test	14.09.2007	14.09.2007	no problem	☑
Rain penetration test		15.10.2007	15.10.2007	no problem	☑
Mechanical load test		10.10.2007	10.10.2007	no problem	☑
Impact resistance test		07.01.2008	07.01.2008	max drop height 2.0 m	
Final inspection, dismantling		16.10.2007	16.10.2007	no changes observed	☑

Emmerthal, 17.04.2008

pp

Dipl.-Ing. C. Lampe, Head of Test Centre-EN

2. Description of the Collector

2.1. Collector

Manufacturer	KBB Kollektorbau GmbH Bruno-Bürgel-Weg 142-144, D- 12439 Berlin
Type	EasySun II
Construction	flat plate collector, Serial type
Year of production	2007
Serial number	00150002
Weight, empty, without glazing	18.6 kg (according to manufacturer)
Weight, empty, with glazing	33.5 kg (weighed at ISFH)

2.2. Glazing

Number of glazings	one
Dimensions	1844 mm x 1125 mm x 3.2 mm
Material	safety glass, low iron; with structure, manufacturer: AFG, type Solartex
Aperture area	1.808 m x 1.087 m = 1.965 m²
Solar transmittance	τ = 91.5% (according to manufacturer)

2.3. Absorber

Absorber material	aluminium plate, thickness 0.5 mm (according to manufacturer)
Material of fluid tubes	copper, d_i /d_a= 7.2 / 8 mm
Connection between absorber and tubes	laser welding
Hydraulic construction	two series-connected groups of 5 parallel tubes, tube distance approx. 110 mm
Absorber layer	selective (BlueTec, type eta plus-Al)
Solar absorptance	α = 94±2 % (according to manufacturer)
Hemispherical emittance	ε = 5±2 % (according to manufacturer)
Absorber dimensions	1.825 x 1.100 m² = 2.008 m² (according to manufacturer)

2.4. Heat Transfer Fluid

Specifications	water/propylene glycol
Alternative acceptable heat transfer fluids	no details
Fluid content	1.16 l (weighed at ISFH)

2.5. Casing

Dimensions (L / W / H)	1870 / 1150 / 95 mm
Material of frame	aluminium profiles
Material of back plate	aluminium sheet
Sealing material between the frame segments	silicone

Sealing material between the frame and the glazing	silicone

2.6. Insulation

Insulation construction	plate, Isover, type Ultimate
Insulation material	mineral wool
Thickness	50 mm

2.7. Reference Areas

Absorber area	1.963 m² (partially limited by the aperture area)
Aperture area	1.965 m²
Gross area	2.175 m²

2.8. Collector Mounting

Collector tilt angle	20°..90°
On sloped roof	yes
Integrated into sloped roof	yes
On flat roof	no
On flat roof with stand	yes
Facade	yes

2.9. Limitations

Stagnation temperature	230 °C (according to manufacturer; new determination in section 8.4 of this report)
Maximum pressure	10 bar

3. Validity

This test report is valid for the collector (description see section 2) with the serial number 00150002.

3.1. Tests carried over

1. The tests were carried out at the collector type K420-DH of the company KBB Kollektorbau GmbH (test report no. 87-07/Q) which is identical in construction compared to the collector type EasySun II. With this report the test results are carried over to the collector type EasySun II of the company Paradigma s.r.l..
2. The mechanical load test was done at the collector K420-MS reported in test report no. 89-07/Q which is identical in construction with respect to the casing and glazing (see section 8.8).

4. Photograph of the Collector

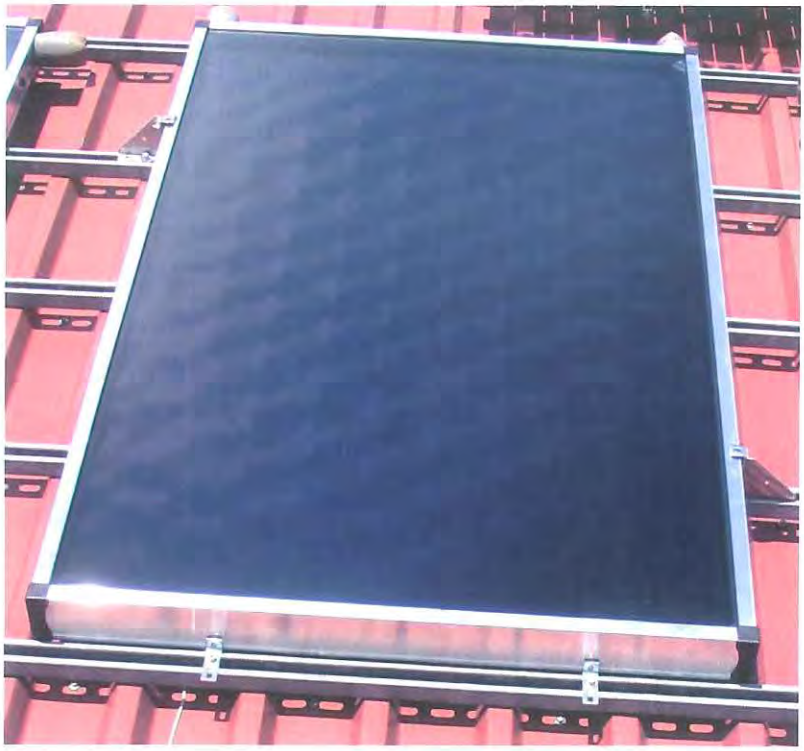


Fig. 4-1: Picture of the collector

5. Sampling

Date of sampling:	25.07.2007
Place of sampling:	Factory stock of the company KBB Kollektorbau GmbH, Bruno-Bürgel-Weg 142-144, D- 12439 Berlin, Germany
Inspector:	Carsten Lampe (employee of the Test Centre)

Description of sampling:

The collector with the serial number 00150002 was chosen out of 8 identical products. The collector was marked in the store ("ISFH-TEST"Label number 02260) and on the 27.07.2007 delivered to the test centre. The manufacturer has proved through his factory production control and his quality management system conformity of the test sample with the series production.

6. Documents; Collector Identification

Drawings: The following drawings were presented by the customer
- 42002005$0
- 18041605$0

Collector data sheet: A data sheet with details about the tested collector was presented by the customer.

Labelling of the collector: The test collector has a visible and durable type label.

Installer instruction manual: The following documents were presented by the customer:
- Installation instruction for mounting (Date: 2007)
- Installations instructions (Date: 12/2007)
- Technical data sheet (Date: 12/2007)

7. Inspection upon Arrival and Installation of Sensors

The collector has been delivered in a faultless condition. After the delivery, the collector was visually inspected and equipped with one temperature sensor (Pt 100, class A), at 2/3 of the height and 1/2 of the width of the absorber. The sensor measures the absorber temperature. Care was taken that the sensor does not influence the results of the following tests.

8. Reliability Tests

8.1. First Internal Pressure Test of Absorber

Date:	01.08.2007	
Test facility:	mobile pressure test facility	
Inspector:	Carsten Lampe (employee of the Test Centre)	
Test conditions	Conditions stipulated in EN 12975-2	Test conditions
Test pressure	$1.5 \cdot p_{max}$ = 15 bar	16 bar
Ambient temperature	5 °C... 30 °C	20 °C
Test period	at least 15 min.	18 min.
Result		
After the first internal pressure test, **no problem** was observed.		

8.2. Exposure Test

Date:	01.08.2007 to 15.10.2007
Test facility:	test roof 1 (azimuth = 0°, facing south)
Inspector:	Nele Rumler (employee of the test centre)
Collector tilt angle:	38°

Test conditions	Conditions stipulated in EN 12975-2	Test conditions
Global daily irradiation (in the collector plane)	at least 30 days with > 14 MJ/m²d	43 days
Global irradiance	at least 30 h with > 850 W/m²	51.5 hours
Ambient temperature	> 10°C	> 10 °C

Results

Collector component	Potential problem/ **Observation**[1]	Evaluation[2]
Collector box / fasteners	Cracking / warping / corrosion / rain penetration	0
Mountings / structure	Strength / safety	0
Seals / gaskets	Cracking / adhesion / elasticity	0
Cover / reflector	Cracking / crazing / buckling / delamination / warping / outgassing	0
Absorber coating, absorber tubes and headers, absorber mountings	Cracking / crazing / blistering/ deformation / corrosion / leakage / loss of bonding	0
Insulation	Water retention / outgassing / degradation	-[3]

1. Observations are printed in bold.
2. Scale of evaluations:
   0 = no problem
   1 = minor problem;
   2 = severe problem
3. This will be checked during the final dismantling because the collector has to be opened for this purpose.

Details of the climatic conditions during the exposure test are given in table A-1 and table A-2.

8.3. High Temperature Resistance Test

Date:	23.08.2007
Test facility:	test roof 1 (azimuth = 0°, facing south)
Inspector:	Carsten Lampe (employee of the Test Centre)
Collector tilt angle:	38°

Test conditions	Conditions stipulated in EN 12975-2	Test conditions
Duration of test	≥ 60 min	60 min
Mean global irradiance[1]	> 1000 W/m²	1008 W/m²
Mean ambient temperature	20...40 °C	27.9 °C
Mean surrounding air speed	< 1 m/s	< 1 m/s
Mean absorber temperature[2]	-	190.4 °C

Result

During and after the test, **no problem** was observed.

1. With the test conditions of 1008 W/m² and 27.9 °C the thermal load is higher than the minimal requirement of 1000 W/m² and 20 °C stipulated in EN 12975-2.
2. Position of the temperature sensor: see section 7.

8.4. Determination of the Stagnation Temperature

During the exposure test before the performance test of the collector with the serial number 00150026 (test report no. 86-07/D), the stagnation temperature was determined.

8.4.1. Mathematical Procedure[a]

$$t_{stg} = a \cdot G_s^{\frac{1}{1.3}} + t_{as} \qquad \text{eqn. (8.1)}$$

t_{stg} = stagnation temperature under standard conditions in °C
G_s = standard global irradiance
t_{as} = standard ambient temperature

$$a = \frac{(t_{sm} - t_{am})}{G_m^{1/1.3}} \qquad \text{eqn. (8.2)}$$

t_{sm} = measured absorber temperature in °C
t_{am} = measured ambient temperature in °C
G_m = measured global irradiance (in the collector plane) in W/m²

a. For the calculation of the stagnation temperature under standard conditions, the eqns. (8.1) and (8.2) are used, as this method has a lower uncertainty than the procedure described in EN 12975-2.

8.4.2. Test Conditions and Results

Date:	08.08.2007		
Test facility:	SUSI I (indoor test with sun simulator)		
Inspector:	Gerd Schiewe (employee of the test centre)		
Collector tilt angle:	45°		
	Test conditions	Standard conditions according to ISO 9806-2	
		Class A (temperate), corresponding to conditions stipulated in EN 12975-2	Class B (sunny)
Global irradiance	823 W/m²	1000 W/m²	1100 W/m²
Surrounding air speed	< 1 m/s	< 1 m/s	< 1 m/s
Ambient temperature	29.3 °C	30 °C	40 °C
Measured absorber temperature (t_{sm})	177.8 °C		
Calculated stagnation temperature (t_{stg})		**203 °C**	226 °C

8.5. Thermal Shock Tests

8.5.1. External Thermal Shock Tests

Date:	14.08.2007 (1. Test) and 14.09.2007 (2. Test)
Test facility:	Test roof 1 (azimuth = 0°, facing south)
Inspector:	Carsten Lampe (employee of the Test Centre)
Collector tilt angle:	38°

Test conditions	Conditions stipulated in EN 12975-2	Test conditions	
		1. Test	2. Test
Duration of test	≥ 75 min	75 min	75 min
Mean global irradiance	-	986 W/m²	966 W/m²
Lowest global irradiance	> 850 W/m²	> 850 W/m²	> 850 W/m²
Mean ambient temperature	-	26.0 °C	19.6 °C
Lowest ambient temperature	> 10 °C	> 10 °C	> 10 °C
Temperature of spraying water	< 25 °C	16.0 °C	15.3 °C
Mass flow rate of spraying water	0.03...0.05 kg/sm²	0.04 kg/sm²	0.05 kg/sm²
Duration of spraying	≥ 15 min	15 min	15 min
Absorber temperature[1] before spraying	-	195.9 °C	173.9 °C

Results

During and after the test, **no problem** was observed.

1. Position of the temperature sensor: see section 7.

8.5.2. Internal Thermal Shock Tests

Date:	06.08.2007 (1. Test) and 24.09.2007 (2. Test)
Test facility:	Test roof 1 (azimuth = 0°, facing south)
Inspector:	Carsten Lampe/ Nele Rumler
Collector tilt angle:	38°

Test conditions	Conditions stipulated in EN 12975-2	Test conditions 1. Test	Test conditions 2. Test
Duration of test	≥ 65 min	66 min	66 min
Mean global irradiance	-	1030 W/m²	957 W/m²
Lowest global irradiance	> 850 W/m²	> 850 W/m²	> 850 W/m²
Mean ambient temperature	-	29.1 °C	23.8 °C
Lowest ambient temperature	> 10°C	> 10 °C	> 10 °C
Temperature of water	< 25 °C	17.1 °C	15.4 °C
Mass flow rate of heat transfer fluid	≥ 0.02 kg/sm²	0.02 kg/sm²	0.02 kg/sm²
Duration of circulation	≥ 5 min	6 min	6 min
Absorber temperature[1] before the shock	-	189.9 °C	177.3 °C

Results

During and after the test, **no problem** was observed.

1. Position of the temperature sensor: see section 7.

8.6. Second Internal Pressure Test of Absorber

Date:	15.10.2007
Test facility:	mobile pressure test facility
Inspector:	Carsten Lampe (employee of the Test Centre)

Test conditions	Conditions stipulated in EN 12975-2	Test conditions
Test pressure	$1.5 \cdot p_{max}$ = 15 bar	15 bar
Ambient temperature	5 °C... 30 °C	19 °C
Duration of test	at least 15 min	15 min

Result

After the second internal pressure test, **no problem** was observed.

8.7. Rain Penetration Test

Date:	15.10.2007
Test facility:	rain test facility, with open frame
Inspector:	Nele Rumler (employee of the test centre)
Collector tilt angle:	20°

Test conditions	Conditions stipulated in EN 12975-2	Test conditions
Duration of test	≥ 4.5 h	4.8 h
Mean ambient temperature	-	17 °C
Water temperature (spraying water)	< 30 °C	14 °C
Mass flow rate of spraying water	≥ 0.05 kg/sm²	0.06 kg/sm²
Duration of spraying	4 h	4.3 h
Absorber temperature	-	ca. 55 °C

Result

After the rain penetration test, **no problem** was observed.

During the final dismantling (see section 9), humidity was not observed inside the distributer casing and in the tubes of the collector.

8.8. Mechanical Load Test

The mechanical load test was done at the collector K420-MS with the serial number 00150017 (test report no. 89-07/Q) which is identical in construction with respect to the glazing and casing.

8.8.1. Positive Pressure Test of the Collector Cover

The test is intended to assess the extent to which the transparent cover of the collector and the collector box are able to resist the positive pressure load due to the effect of wind and snow. The positive pressure load was applied by a uniformly distributed set of 15 suction cups.

Tab. 8-1: Positive pressure test on collector cover

Date:	10.10.2007	
Test facility:	mechanical load test facility MARTA	
Inspector:	Carsten Lampe (employee of the Test Centre)	
Collector tilt angle:	0°	
Test conditions	Conditions stipulated in EN 12975-2	Test conditions
Maximum positive pressure	1000 Pa	3000 Pa
Result		
During and after the test, **no problem** was observed.		

After the test with the regular roof hooks the test was repeated with hooks for heavy duty.

Tab. 8-2: Positive pressure test on collector cover with hooks for heavy duty

Date:	10.10.2007	
Test facility:	mechanical load test facility MARTA	
Inspector:	Carsten Lampe (employee of the Test Centre)	
Collector tilt angle:	0°	
Test conditions	Conditions stipulated in EN 12975-2	Test conditions
Maximum positive pressure	1000 Pa	5000 Pa
Result		
During and after the test, **no problem** was observed.		

8.8.2. Negative Pressure Test of the Collector

The test is intended to assess the extent to which the fixings between the collector cover and collector box and the collector mountings are able to resist uplift forces caused by the wind. The lifting force which is equivalent to the specified negative pressure load is applied by a uniformly distributed set of 15 suction cups.

Tab. 8-3: Negative pressure test of the collector mountings

Date:	10.10.2007	
Test facility:	Mechanical load test facility	
Inspector:	Carsten Lampe (employee of the Test Centre)	
Collector tilt angle:	0°	
Test conditions	Conditions stipulated in EN 12975-2	Test conditions
Maximum negative pressure	1000 Pa	3000 Pa
Result		
During and after the test, **no problem** was observed.		

After the test with the regular roof hooks the test was repeated with hooks for heavy duty.

Tab. 8-4: Negative pressure test of the collector mountings with hooks for heavy duty

Date:	10.10.2007	
Test facility:	Mechanical load test facility	
Inspector:	Carsten Lampe (employee of the Test Centre)	
Collector tilt angle:	0°	
Test conditions	Conditions stipulated in EN 12975-2	Test conditions
Maximum negative pressure	1000 Pa	2750 Pa
Result		
During and after the test, **no problem** was observed.		

8.9. Impact Resistance Test (optional test)

This test is optional according to EN 12975-1:2006. It was carried out on request of the customer.

In this test, a steel ball (diameter 31 mm, mass 150 g) is dropped onto the a vacuum tube from different heights.

Tab. 8-5: Impact resistance test

Date:	07.01.2008								
Test facility:	Impact resistance test facility								
Inspector:	Carsten Lampe (employee of the Test Centre)								
Collector tilt angle:	0°								
Test conditions (as stipulated in EN 12975-2)									
Drop height in m	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
Number of drops	10	10	10	10	10	10	10	10	10
Result									
The maximum drop height is 2 m.									

9. Final Inspection and Dismantling

The collector was dismantled. It was inspected with regard to changes, weak points and correspondence with the drawings.

9.1. Observations and Evaluations of the Final Inspection

Date of final inspection:	16.10.2007	
Inspector:	Carsten Lampe (employee of the Test Centre)	
Collector component	Potential problem/ **Observation**[1]	Evaluation[2]
Collector box / fasteners	Cracking / warping / corrosion / rain penetration	0
Mountings / structure	Strength / safety	0
Seals / gaskets	Cracking / adhesion / elasticity	0
Cover/ reflector	Cracking / crazing / buckling / delamination / warping / outgassing	0
Absorber coating, absorber tubes and headers, absorber mountings	Cracking / crazing / blistering/ deformation / corrosion / leakage / loss of bonding	0
Insulation	Water retention / outgassing / degradation	0

1. Observations are printed in bold.
2. Scale of evaluations:
   0 = no problem
   1 = minor problem;
   2 = severe problem

There were no extraordinary incidents during the tests.

No sharp edges, loose fixing elements or other characteristics representing a possible endangering, were observed.

10. Stipulations from the Test Centre

1. This test report is valid for the collector (description see section 2) with the serial number 00150002.
2. Prior to passing on to others or reproducing parts of this test report, permission must be obtained. Passing on the single page 3 or the complete test report is generally approved.

Test Centre for Solar Thermal
Components and Systems

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Appendix A: Test Conditions during Exposure

Tab. A-1: Days with global irradiation on collector plane exceeding 14 MJ/m²

day no.	date	global irradiation in MJ/m²	ambient temperature[1] in °C	rainfall in mm
1	01.08.2007	26.52	19.3	0
2	03.08.2007	17.26	19.1	0.1
3	04.08.2007	27.03	21.6	0
4	05.08.2007	28.25	23.7	0
5	06.08.2007	28.65	25.9	0
6	11.08.2007	23.62	20.3	0.8
7	12.08.2007	21.02	19.9	0
8	13.08.2007	18.44	19.8	0
9	14.08.2007	25.79	21.8	0
10	15.08.2007	14.29	23.2	0.1
11	16.08.2007	23.81	16.4	0
12	17.08.2007	17.59	16.4	0.3
13	18.08.2007	17.78	18.4	0.1
14	19.08.2007	15.12	19.5	0.2
15	20.08.2007	16.05	20.0	0.1
16	22.08.2007	15.14	20.1	2
17	23.08.2007	17.13	21.2	1.6
18	24.08.2007	17.56	22.2	6.4
19	25.08.2007	18.23	22.3	0
20	26.08.2007	17.41	20.5	0
21	27.08.2007	19.14	18.0	0
22	28.08.2007	20.59	18.1	0.1
23	29.08.2007	17.68	15.7	0
24	03.09.2007	14.23	15.4	0.2
25	04.09.2007	14.98	12.9	4.2
26	05.09.2007	20.81	16.2	0
27	06.09.2007	16.82	18.8	0.3
28	11.09.2007	16.16	17.5	1.9
29	14.09.2007	21.6	14.8	1.5
30	15.09.2007	20.63	15.7	0
31	16.09.2007	23.81	17.6	0
32	19.09.2007	17.22	12.7	0
33	20.09.2007	16.22	16.0	0
34	21.09.2007	14.43	18.4	0
35	22.09.2007	23.14	19.7	0
36	23.09.2007	22.32	19.9	0.1
37	24.09.2007	20.86	20.9	0.6
38	25.09.2007	15.57	14.5	2.7
39	07.10.2007	18.31	12.0	0.2
40	10.10.2007	18.81	14.9	0
41	13.10.2007	18.43	14.2	0
42	14.10.2007	21.63	14.0	0
43	15.10.2007	20.51	15.2	0

1. Mean ambient temperature from sunrise to sunset

Tab. A-2: Time periods when conditions for the 30-h exposure test were fulfilled[a]

day no.	date	global irradiance[1] in W/m²	ambient temperature[1] in °C	hours on this day	sum of hours
1	01.08.2007	984.0	23.7	2.5	2.5
2	03.08.2007	939.6	22.8	0.5	3.0
3	04.08.2007	975.5	26.4	2.5	5.5
4	05.08.2007	984.5	28.0	3.5	9.0
5	06.08.2007	991.3	29.1	3.5	12.5
6	11.08.2007	1003.7	24.3	3.5	16.0
7	12.08.2007	979.8	25.2	2.5	18.5
8	13.08.2007	990.3	23.5	1	19.5
9	14.08.2007	1024.4	25.9	2.5	22.0
10	15.08.2007	926.0	26.8	0.5	22.5
11	17.08.2007	946.3	20.2	0.5	23.0
12	22.08.2007	988.6	23.7	1.5	24.5
13	23.08.2007	966.3	27.4	2	26.5
14	24.08.2007	970.7	28.5	1	27.5
15	29.08.2007	960.5	19.6	1	28.5
16	30.08.2007	945.8	17.6	0.5	29.0
17	03.09.2007	1010.1	20.6	1	30.0
18	04.09.2007	975.8	16.7	1	31.0
19	06.09.2007	945.9	24.5	1	32.0
20	14.09.2007	972.8	18.9	2.5	34.5
21	16.09.2007	935.3	20.8	2	36.5
22	19.09.2007	954.8	15.5	0.5	37.0
23	20.09.2007	939.5	17.6	0.5	37.5
24	22.09.2007	942.1	23.0	2.5	40.0
25	23.09.2007	931.2	24.5	1.5	41.5
26	24.09.2007	934.2	23.8	2	43.5
27	25.09.2007	977.7	16.4	1	44.5
28	07.10.2007	909.4	17.1	2	46.5
29	10.10.2007	885.0	18.6	0.5	47.0
30	13.10.2007	892.7	17.6	1	48.0
31	14.10.2007	894.2	17.1	2	50.0
32	15.10.2007	879.1	17.8	1.5	51.5

1. Mean values of the time periods during which the test conditions were fulfilled

a. Global irradiance on the collector plane > 850W/m² and ambient temperature > 10°C