

Ordered by:

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Test Report No. C1091LPEN

Performance test according to EN 12975-2:2006, Paragraph 6

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1 Description of Collector

1.1 Technical Data of the Sample

Product information	
Manufacturer	Wuxi Wankang Solar Water Heater Co., Ltd.
Model	CD-1800/58-12Tubes
Type	Evacuated tube collector
Flow	Heat Pipe
Serial product	Yes
Drawing number	A complete set of technical drawings is filed at the test institute.
Serial number	*)
Date of manufacture	08.02.2009

Physical parameters	
Gross length	1.984 m
Gross width	1.016 m
Gross height	0.185 m
Gross area	2.016 m ²
Aperture area	1.395 m ²
Absorber area	2.328 m ²
Weight empty	51.0 kg
Fluid capacity	0.8 l

Construction	
Type	Evacuated tube collector
Number of absorber elements	12
Absorber pitch	80.0 mm
Number of hydraulically parallel tubes	1
Number of thermally serial glazings	1
Material of glazing(s)	Borosilicate glass
Thickness of glazing(s)	2.2 mm

Heat transfer fluid (manufacturers' recommendation)	
Type	Water-glycol
Specifications	--

Flow range (manufacturers' recommendation)	
Flow range	180 - 480 l/h
Rated flow rate	360 l/h

Absorber	
Absorber element	Evacuated double glass tube
Length of absorber element	1707.0 mm
Width of absorber element	46.0 mm
Thickness of absorber element	1.60 mm
Coating	Cu/al/ss
Flowed through element	Copper pipe/Heat pipe
Joining technique	--
Joining seam	--

Installation	
On tilted roof	Yes
In tilted roof	No
On flat roof	No
On flat roof with stand	Yes
Facade	No

Casing and insulation	
Casing material	Aluminium
Sealing material	EPDM
Insulation material	Rockwool compression-moulded
Thickness (in mm)	50
Aperture dimensions	12 * 0.535 m * 0.0536 m + 1.172 m * 0.897 m

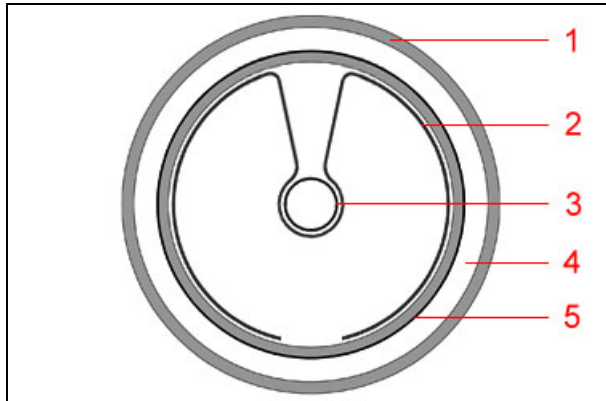
Limitations (manufacturer information)	
Max. temperature	99°C
Max. operating pressure	6 bar
Other	--

Remarks on collector design	
--	

Test schedule	
Test procedure	EN12975:2006, Outdoor test
Sample received	12.05.2009
Start of test	26.08.2009
End of test	16.12.2009

*) No serial number on the tested collector. Meanwhile the manufacturer provides the collector with a proper serial number.

1.2 Sketch of Collector



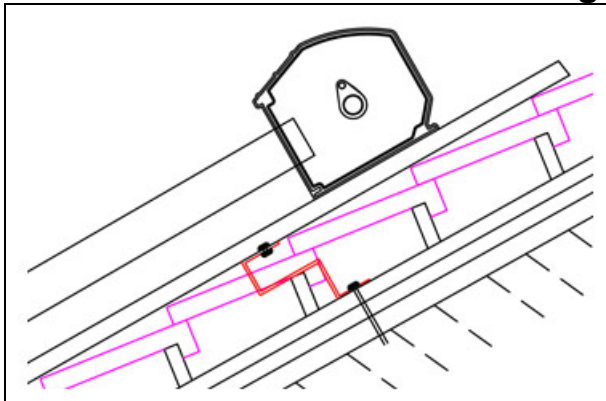
1.3 Specifications on Elements

1	Glazing	
	Material:	Borosilicate glass
	Thickness [mm]:	2.2
2	Heat-conducting metal sheet	
	Description:	Aluminum
3	Heat pipe	
	Description:	Copper
4	Vacuum	
5	Absorber	
	Absorber element:	Evacuated double glass tube
	Flow-through element:	Copper pipe/Heat pipe
	Length of element [mm]:	1707
	Width of element [mm]:	46
	Flow type:	Serial
5	Absorber coating	
	Description:	Cu/al/ss

1.4 Photo of Collector



1.5 Sketch of Collector Mounting



2 Test Methods and Results

2.1 Test of Thermal Performance

Tests carried out according to EN 12975-2: 2006.

Deviations from this standard are indicated by the same formatting that is used for this clause. The reasons for the deviations are mentioned.

2.2 Schematic of the Test Loop

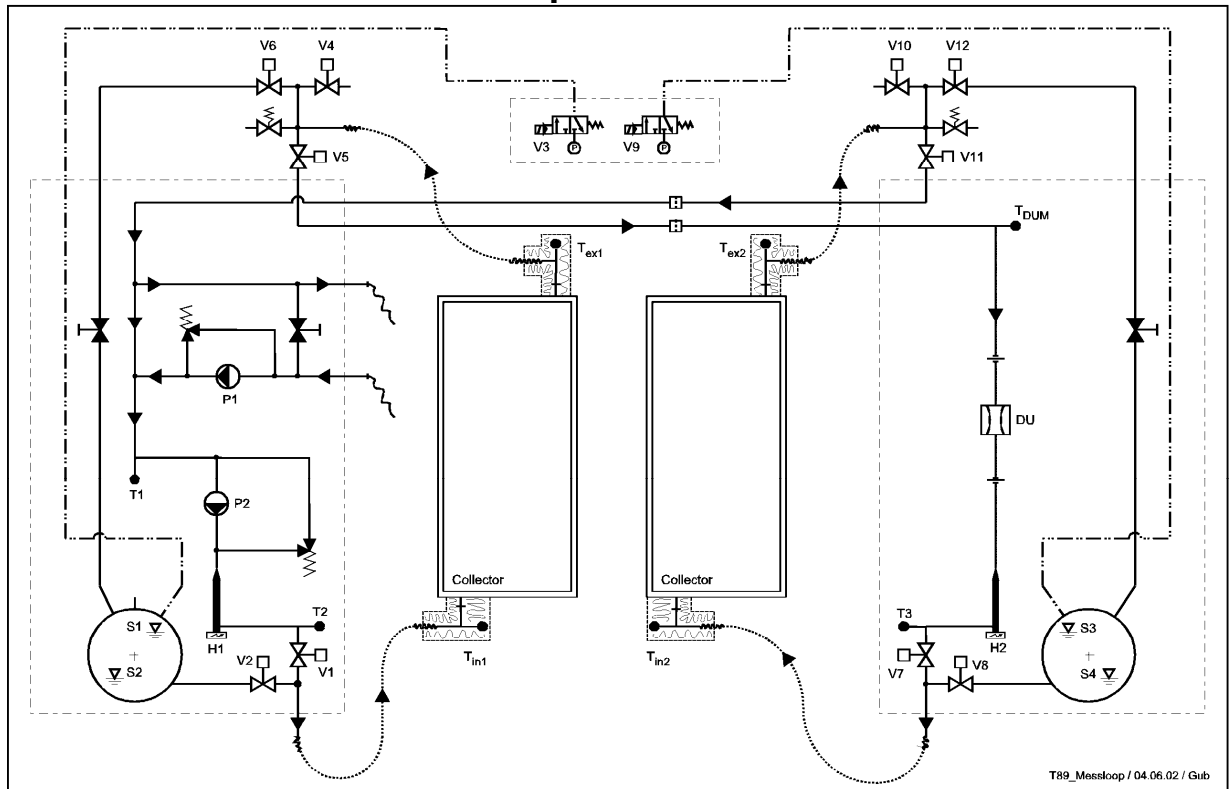


Fig. 2.1: Test loop for efficiency measurements.

2.3 Power Output

2.3.1 General

Flow rate during test	100.0 l/h
Fluid for tests	33.3 Vol-% ethylene glycol
Test method	stationary (steady state)
Geographical position of test site	47.2°N / 8.8°O, 417 m NN
Collector tilt angle	tracked (45±5)°
Collector azimuth angle	tracked (0±48)°
Definition of efficiency	$\eta = \dot{Q} / A \cdot G$
Thermal output power of collector	\dot{Q}
Reference area	A
Solar irradiance	G
Solar irradiance on reference area	A · G
Efficiency equation	$\eta = \eta_0 - a_1 \cdot T_m^* - a_2 \cdot G \cdot T_m^{*2}$
Temperature at collector inlet	T_{in}
Temperature at collector outlet	T_{ex}
Ambient temperature	T_a
Mean collector temperature	$T_m = (T_{in} + T_{ex}) / 2$
Reduced collector temperature	$T_m^* = (T_m - T_a) / G$
Solar irradiance for efficiency diagrams	G = 800 W/m ²

2.3.2 Power output per collector unit

2.3.2.1 Peak power

Peak power W_{peak} per collector unit for normal incident irradiation of 1000 Wm^{-2} .

$$W_{\text{peak}} = 873 \text{ [W]}$$

2.3.2.2 Diagram

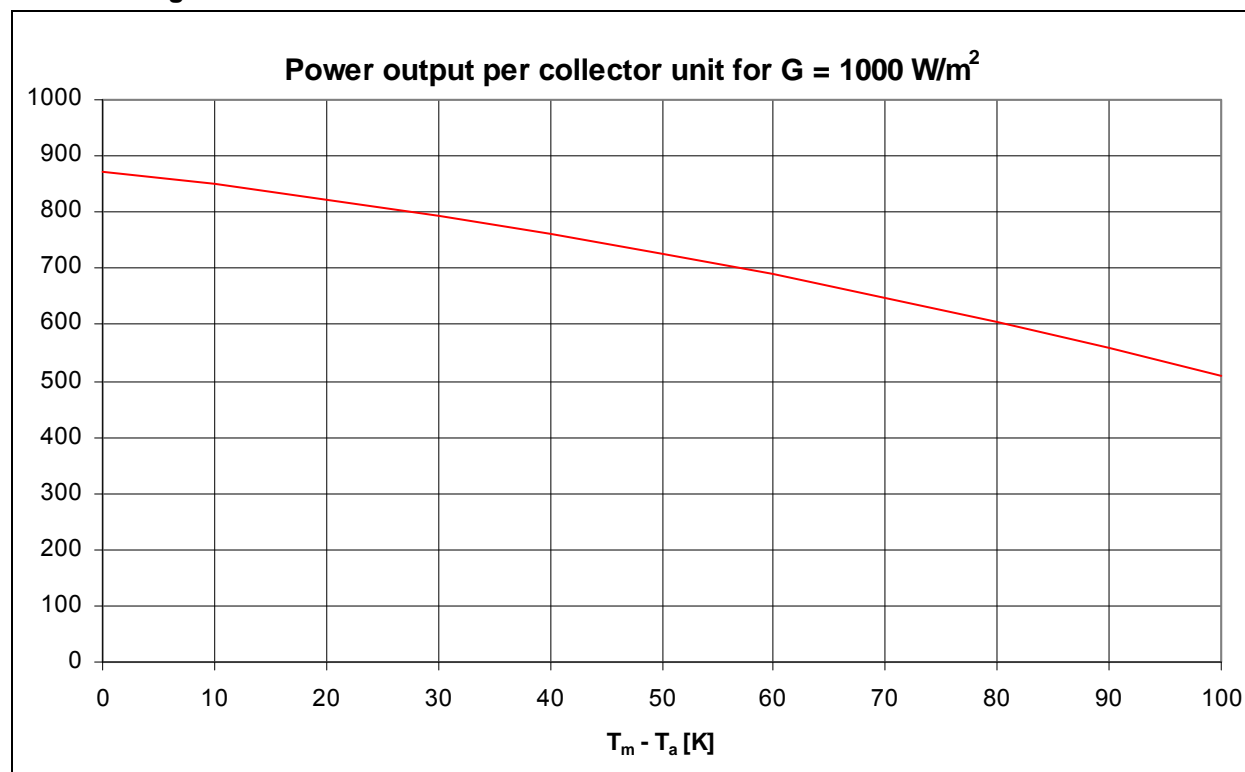


Fig. 2.2: Power output per collector unit at irradiance $G = 1000 \text{ W/m}^2$

2.3.2.3 Power output per collector unit

$T_m - T_a$	Global irradiance G		
	G=400 W/m ²	G=700 W/m ²	G=1000 W/m ²
10 K	326 W	588 W	850 W
30 K	270 W	532 W	794 W
50 K	203 W	465 W	727 W

2.3.3 Efficiency curve

The efficiency curves with reference to the absorber-, aperture- and gross areas are indicated in addition to the requirements of the norm.

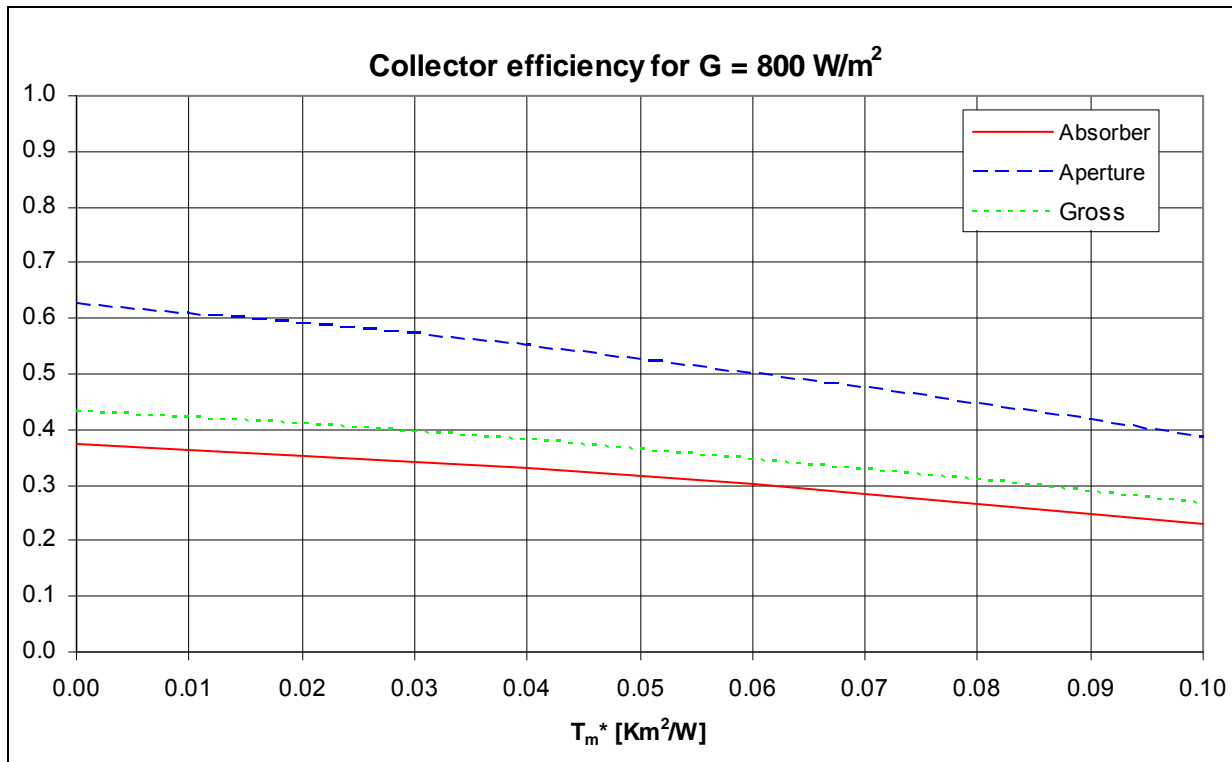


Fig. 2.3: Efficiency diagram for $G = 800 \text{ W/m}^2$

2.3.3.1 Parameters for efficiency equation

Reference area	Absorber area	Aperture area	Gross area
η_0 (-)	0.375	0.626	0.433
a_1 (W/m ² K)	0.94	1.57	1.09
a_2 (W/m ² K ²)	0.0063	0.0105	0.0073

From repetitive measurements of a reference collector, we estimate the following dispersion for the efficiency measurement (standard deviation of the mean, multiplied with a coverage factor 2):

- At $T_m^*=0.02$: 0.27 Efficiency-%,
- at $T_m^*=0.05$: 0.44 Efficiency-%,
- at $T_m^*=0.08$: 0.62 Efficiency-%.

2.4 Incident Angle Factor

2.4.1 Table of the Incidence Angle Modifier (IAM)

	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
K_{Θ} (longitudinal)	1.00	1.00	1.00	0.99	0.98	0.95	0.88	0.75	0.50	0.00
K_{Θ} (transversal)	1.00	1.00	1.02	1.06	1.14	1.24	1.24	0.99	0.55	0.00

2.4.2 Diagram of the Incidence Angle Modifier

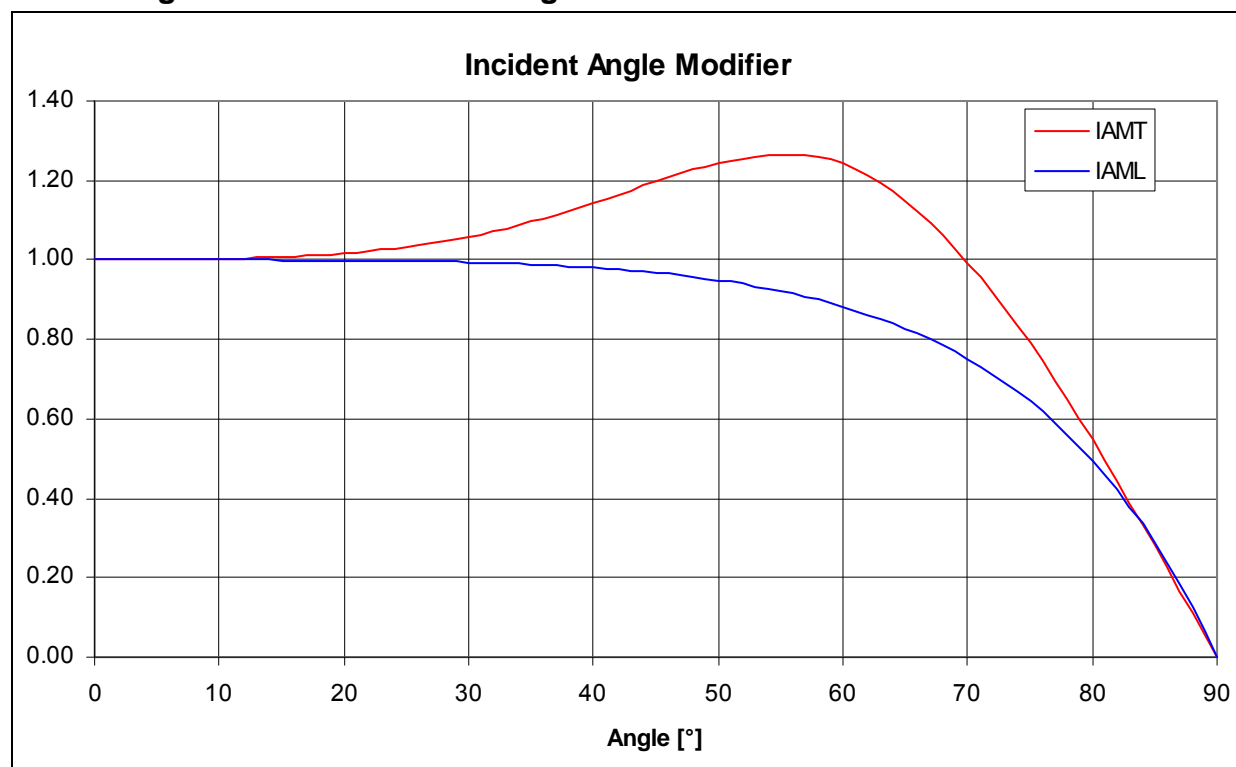


Fig. 2.4: Incident angle modifiers

2.5 Time Constant

$$\tau_c = 737 \text{ s}$$

2.6 Effective Thermal Capacity

2.6.1 Determination according to EN12975-2:2006, Annex G.3

Determination based on transient behaviour of the collector.

$$C_{\text{eff,G3}} = 247.0 \text{ kJ/K (Effective thermal capacity of collector filled with fluid)}$$

Additional information: The thermal capacity was measured with the properties of „Antifrogen N“. For other fluids, the thermal capacity is calculated as follows:

$$C_{\text{eff,G3}} = 0.8 \text{ l} * \text{density} * \text{specific heat capacity of fluid} + 243.9 \text{ kJ/K}$$

2.6.2 Determination according to EN12975-2:2006, Section 6.1.6.2

Estimation based on material properties.

$$C_{\text{eff,G162}} = 17.3 \text{ kJ/K (Effective thermal capacity of collector filled with fluid)}$$

Additional information: The thermal capacity was measured with the properties of „Antifrogen N“. For other fluids, the thermal capacity is calculated as follows:

$$C_{\text{eff,G162}} = 0.8 \text{ l} * \text{density} * \text{specific heat capacity of fluid} + 14.2 \text{ kJ/K}$$

2.7 Pressure Drop

2.7.1 Diagram

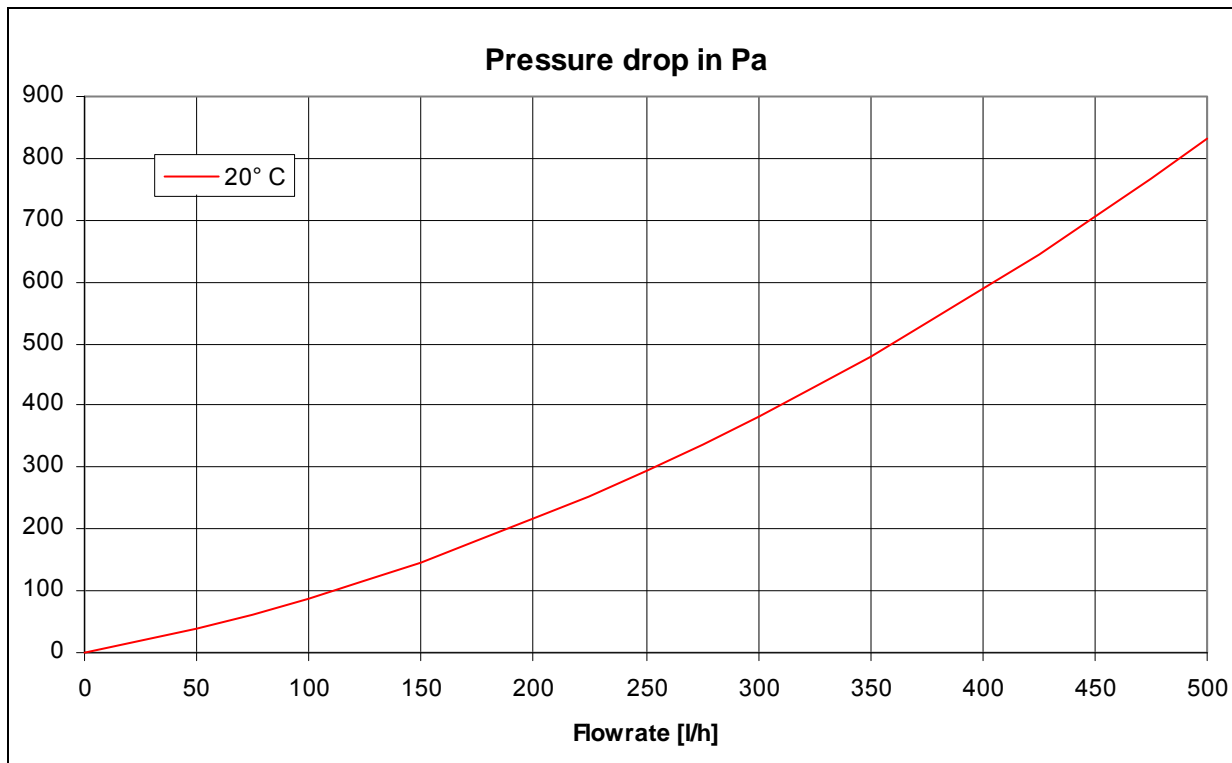


Fig. 2.5: Pressure drop as a function of volume flowrate

2.7.2 Pressure drop at rated flowrate

Conditions:

$T_m = 20^\circ\text{C}$ and $dV/dt = 360 \text{ l/h}$

$\Delta p = 501 \text{ Pa}$

2.7.3 Table of pressure drop data in Pa

Conditions:

$T_m = 20^\circ\text{C}$

Flow rate [l/h]	0	100	200	300	400	500
Pressure drop [Pa]	0	88	216	382	588	832

2.8 Observed Failures

Details about failures that are rated as major failures according to paragraph 5.3.1 of EN12975-1:2006.

Absorber leakage or such deformation that permanent contact between absorber and cover is established.	Passed
Breaking or permanent deformation of cover or cover fixing.	Passed
Breaking or permanent deformation of collector fixing points or collector box.	Passed
Loss of vacuum or low pressure (applicable for vacuum or subatmospheric collectors)	Passed
Accumulation of humidity in form of condensate on the inside of the transparent cover of the collector exceeding 10% of the aperture area	Passed

No major failures according to paragraph 5.3.1 of EN12975-1:2006 were found for this collector.

3 Remarks

This report must not be copied except in full.
The test methods applied fulfil the requirements of EN12975:2006.
The test results only refer to the tested collector sample.
This test report is made according to the requirements of EN12975:2006.
This test report fulfils the requirements of ISO17025.

Rapperswil, 11.03.2010



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