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STS 301

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# Test Report No. C909LPEN

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

**Content:** **page**

# 1 Description of Collector

## 1.1 Technical Data of the Sample

| Product information | |
|---|---|
| Manufacturer | Changzhou He Jia Solar Energy Co., Ltd. |
| Model | HCA-58/30 |
| 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 | HJFPB2007-5-28-3-2 |
| Date of manufacture | 28.05.2007 |

| Physical parameters | |
|---|---|
| Gross length | 1.990 m |
| Gross width | 2.105 m |
| Gross heigth | 0.153 m |
| Gross area | 4.189 m² |
| Aperture area | 2.834 m² |
| Absorber area | 2.432 m² |
| Weight empty | 95.0 kg |
| Fluid capacity | 1.7 l |

| Construction | |
|---|---|
| Type | Evacuated tube collector |
| Number of absorber elements | 30 |
| Absorber pitch | 70.1 mm |
| Number of hydraulically parallel tubes | 1 |
| Number of thermally serial glazings | 1 |
| Material of glazing(s) | Borosilicate glass |
| Thickness of glazing(s) | 1.6 mm |

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

| Flow range (manufacturers' recommendation) | |
|---|---|
| Flow range | 108 - 1200 l/h |
| Rated flow rate | 180 l/h |

| Absorber | |
|---|---|
| Absorber element | Evacuated double glass tube |
| Length of absorber element | 1762 mm |
| Width of absorber element | 47 mm |
| Thickness of absorber element | 1.6 mm |
| Coating | Al-N/Al |
| Flowed through element | Copper pipe/Heat pipe |
| Joining technique | Heat conducting aluminum sheets |
| Joining seam | -- |

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

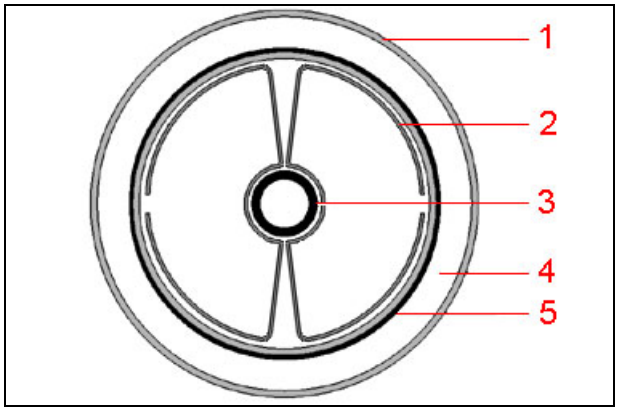
| Casing and insulation | |
|---|---|
| Casing material | Aluminium |
| Sealing material | Silicone |
| Insulation material | Glass wool compression-moulded |
| Thickness (in mm) | 40 |
| Aperture dimensions | 1.724 m * 0.0548 m * 30 |

| Limitations (manufacturer information) | |
|---|---|
| Max. temperature | 250°C |
| Max. operating pressure | 6 bar |
| Other | -- |

| Remarks on collector design |
|---|
| -- |

| Test schedule | |
|---|---|
| Test procedure | EN12975:2006, Outdoor test |
| Sample received | 21.09.2007 |
| Start of test | 02.10.2007 |
| End of test | 12.02.2008 |

## 1.2 Sketch of Collector




## 1.3 Specifications on Elements

**1 Glazing**

| | |
|---|---|
| Material: | Borosilicate glass |
| Thickness [mm]: | 1.6 |

**2 Heat-conducting metal sheet**

| | |
|---|---|
| Description: | Aluminum |

**3 Heat pipe**

| | |
|---|---|
| Description: | Copper |

**4 Vacuum**

**5 Absorber**

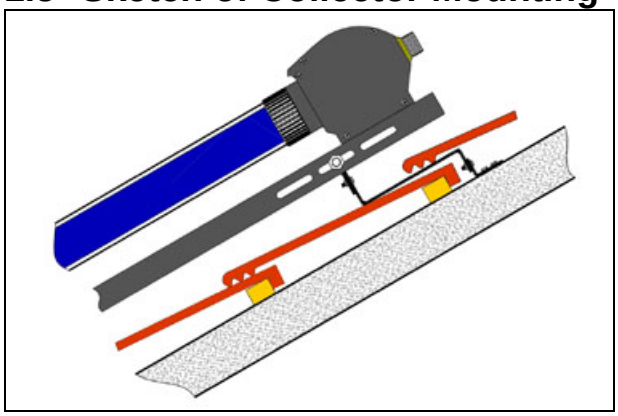
| | |
|---|---|
| Absorber element: | Evacuated double glass tube |
| Flow-through element: | Copper pipe/Heat pipe |
| Length of element [mm]: | 1762 |
| Width of element [mm]: | 47 |
| Flow type: | Serial |
| Joining technique: | Heat conducting aluminum sheets |

**5 Absorber coating**

| | |
|---|---|
| Description: | Al-N/Al |
| Manufacturing process: | Magnetron Sputter CVD |

## 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

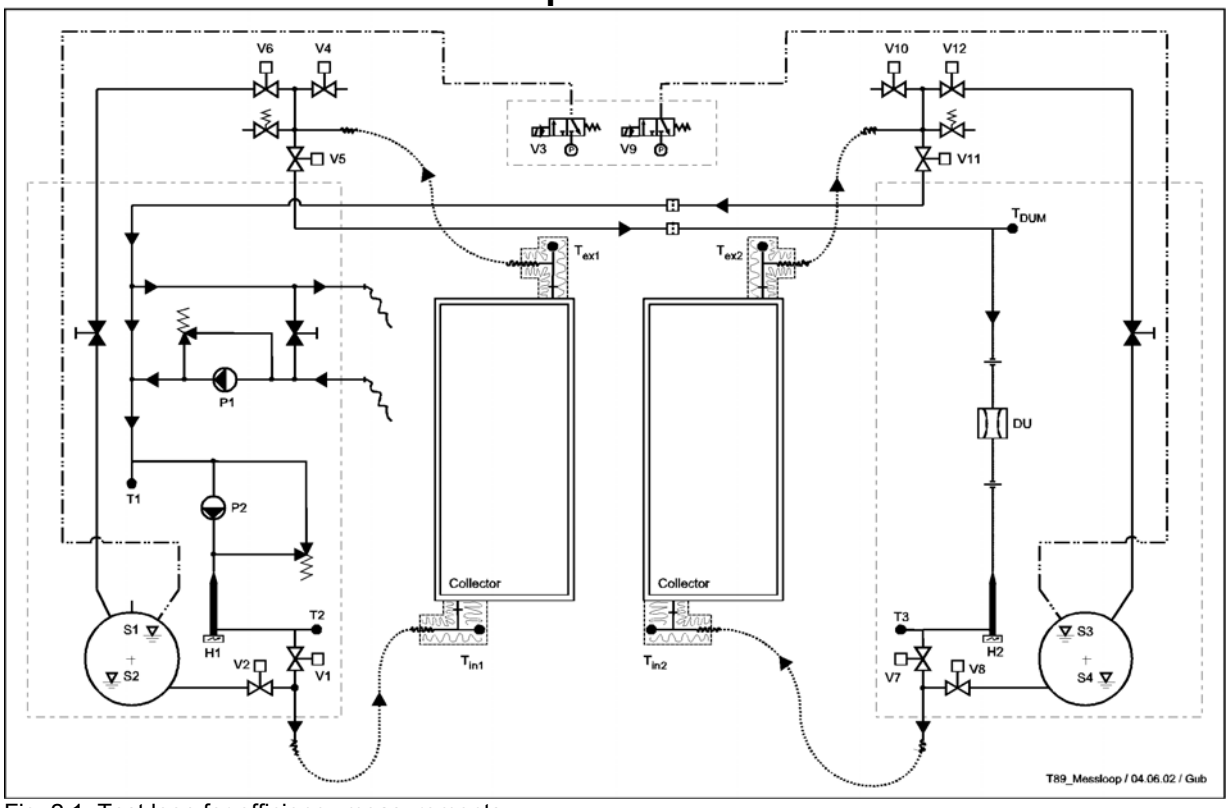



Fig. 2.1: Test loop for efficiency measurements.

## 2.3 Power Output

### 2.3.1 General

| | |
|---|---|
| Flow rate during test | 180.0 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/m² |

## 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 $Wm^{-2}$.

$W_{peak}$ = 1858 [W]

### 2.3.2.2 Diagram

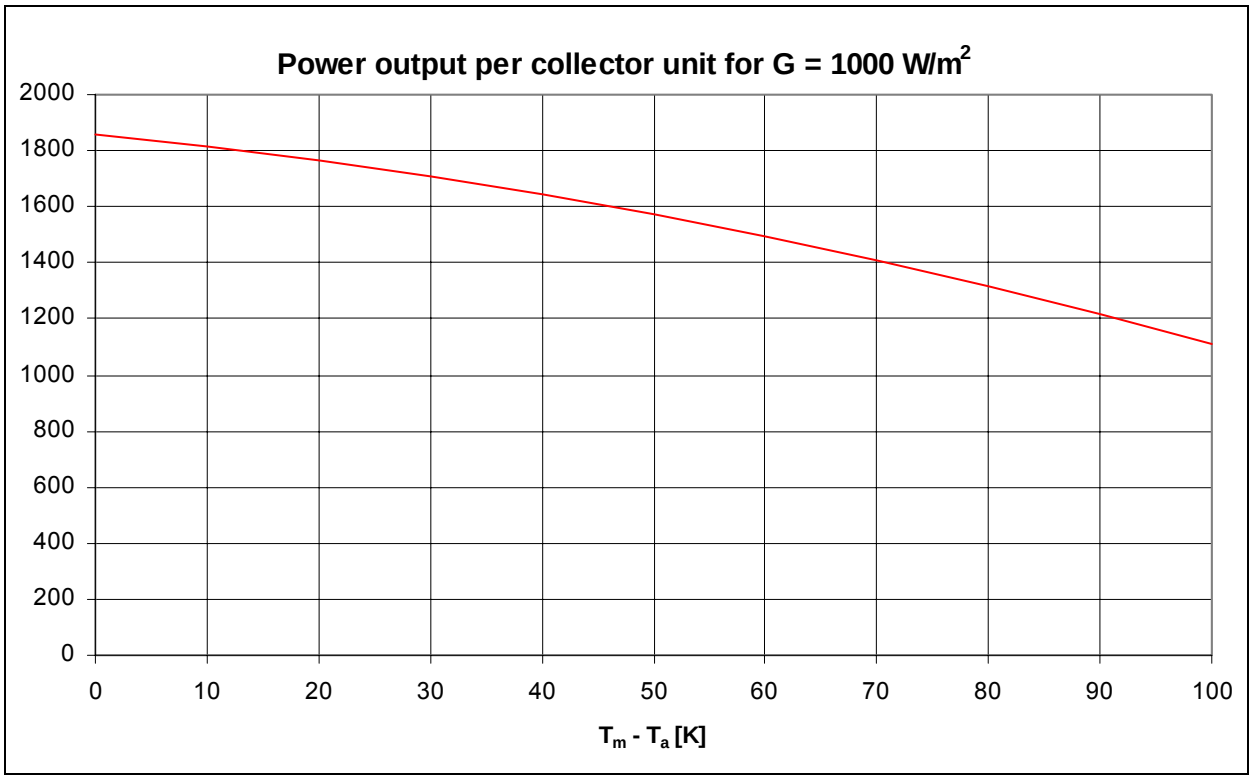



Fig. 2.2: Power output per collector unit at irradiance G = 1000 W/m²

### 2.3.2.3 Power output per collector unit

| $T_m - T_a$ | Global irradiance G | | |
|---|---|---|---|
| | G=400 W/m² | G=700 W/m² | G=1000 W/m² |
| 10 K | 700 W | 1258 W | 1815 W |
| 30 K | 593 W | 1150 W | 1708 W |
| 50 K | 458 W | 1015 W | 1573 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.

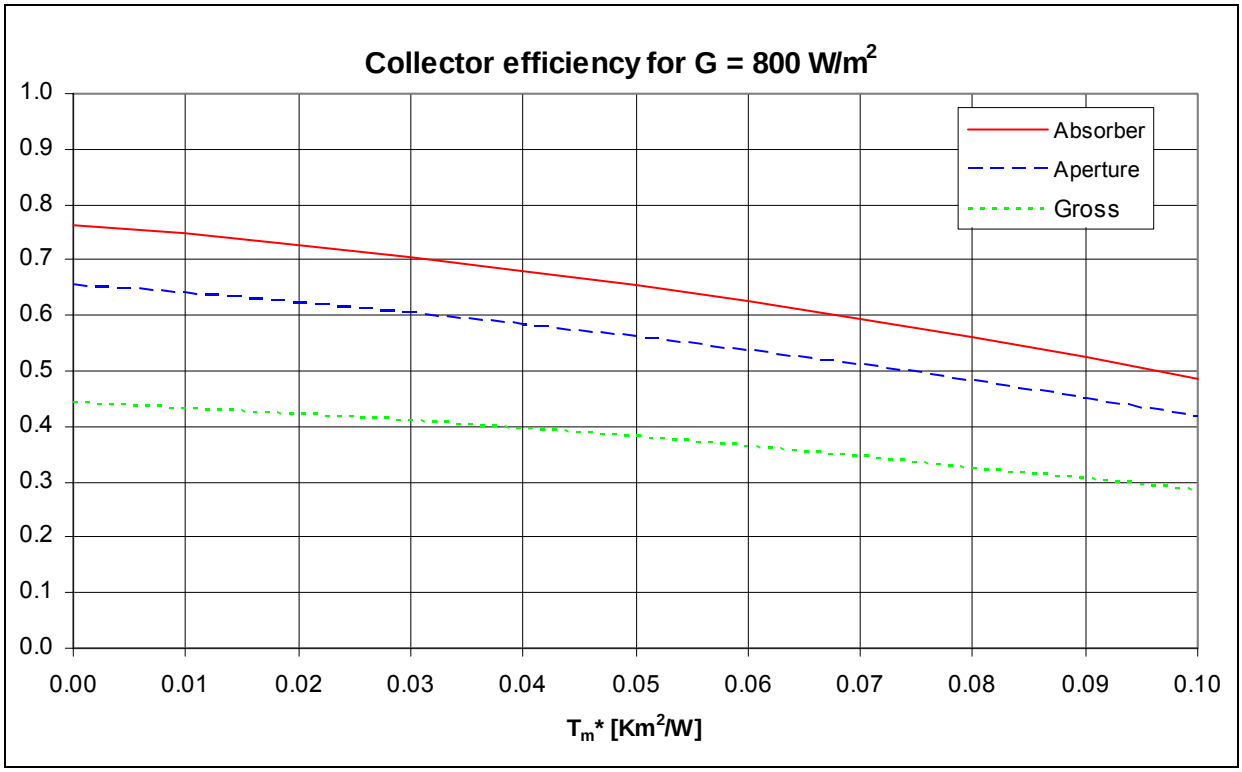



Fig. 2.3: Efficiency diagram for G = 800 W/m²

#### 2.3.3.1 Parameters for efficiency equation

| Reference area | Absorber area | Aperture area | Gross area |
|---|---|---|---|
| $\eta_0$ (-) | 0.764 | 0.656 | 0.444 |
| $a_1$ (W/m²K) | 1.63 | 1.40 | 0.95 |
| $a_2$ (W/m²K²) | 0.0143 | 0.0123 | 0.0083 |

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° |
|---|---|---|---|---|---|---|---|---|---|---|
| $K_\Theta$ (longitudinal) | 1.00 | 1.00 | 1.00 | 0.99 | 0.97 | **0.93** | 0.85 | 0.71 | 0.46 | 0.00 |
| $K_\Theta$ (transversal) | 1.00 | 1.01 | 1.06 | 1.18 | 1.32 | **1.36** | 1.31 | 1.07 | 0.60 | 0.00 |

### 2.4.2 Diagram of the Incidence Angle Modifier

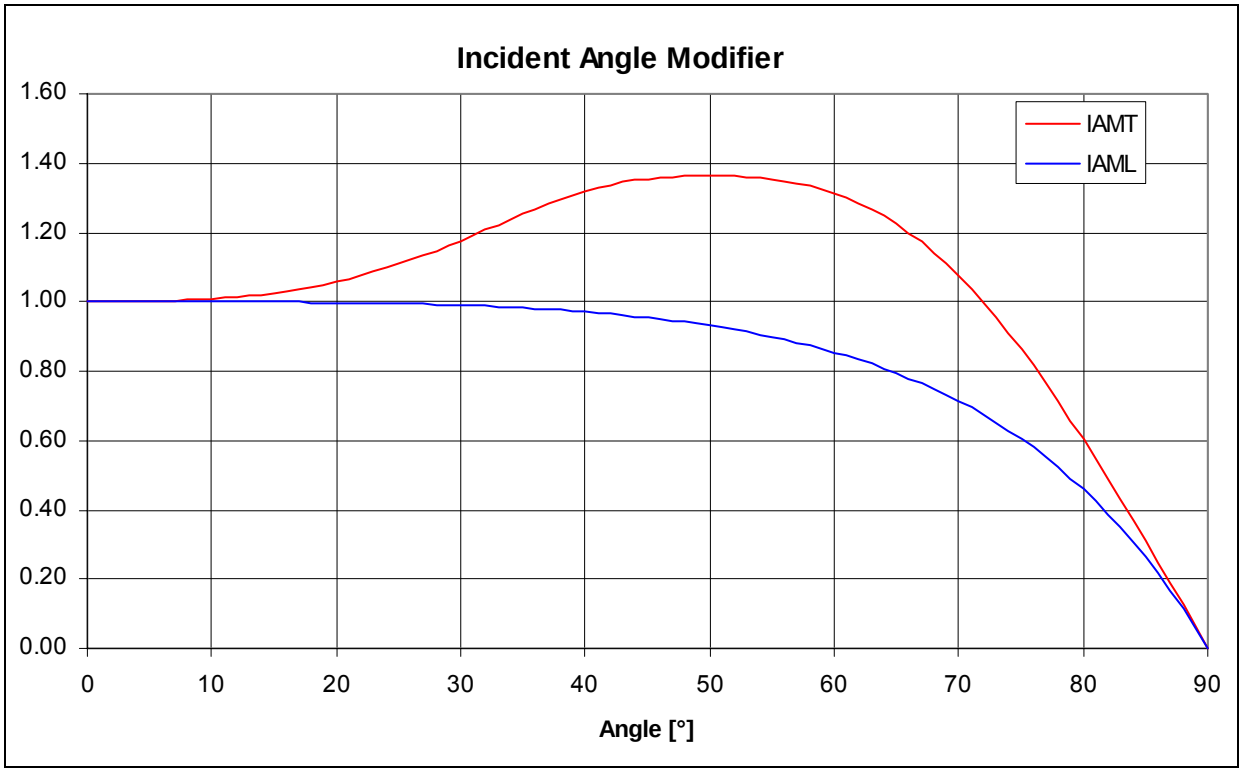



Fig. 2.4: Incident angle modifiers

## 2.5 Time Constant

$\tau_C$ = 795 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.

$C_{eff,G3}$= 295.6 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:

$C_{eff,G3}$ = 1.7 l * density * specific heat capacity of fluid + 289.0 kJ/K

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

Estimation based on material properties.

$C_{eff,6162}$ = 40.3 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:

$C_{eff,6162}$ = 1.7 l * density * specific heat capacity of fluid + 33.7 kJ/K

## 2.7 Pressure Drop

### 2.7.1 Diagram

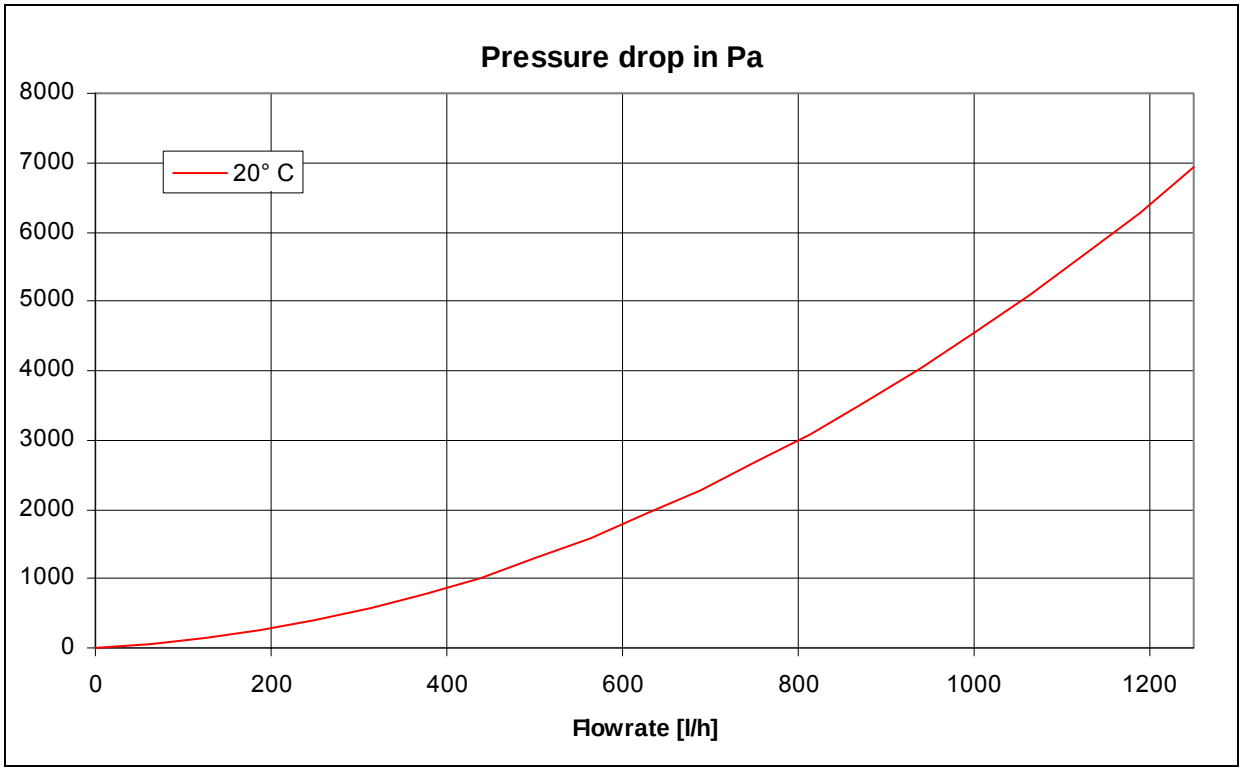



Fig. 2.5: Pressure drop as a function of volume flowrate

### 2.7.2 Pressure drop at rated flowrate

Conditions:
$T_m$ = 20°C and dV/dt = 180 l/h
$\Delta p$ = 234 Pa

### 2.7.3 Table of pressure drop data in Pa

Conditions:
$T_m$ = 20 °C

| Flow rate [l/h] | 0 | 250 | 500 | 750 | 1000 | 1250 |
|---|---|---|---|---|---|---|
| Pressure drop [Pa] | 0 | 394 | 1284 | 2670 | 4550 | 6926 |

## 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, 06.06.2008

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