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Test Report No. C1319LPEN

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 | Thermics S.r.l. |
| Model | 10 DTH-CPC |
| Type | Evacuated tube collector |
| Flow | Direct flow |
| Serial product | Yes |
| Drawing number | A complete set of technical drawings is filed at the test institute |
| Serial number | 11001800015 |
| Date of manufacture | 21.01.2011 |

| Absorber | |
|-------------------------------|-----------------------------|
| Absorber element | Evacuated double glass tube |
| Length of absorber element | 1741.0 mm |
| Width of absorber element | 47.0 mm |
| Thickness of absorber element | 1.50 mm |
| Coating | Cr-Al-N/Cu |
| Flowed through element | Coaxial copper pipe |
| Joining technique | -- |
| Joining seam | -- |

| Physical parameters | |
|---------------------|----------------------|
| Gross length | 1.965 m |
| Gross width | 1.132 m |
| Gross height | 0.140 m |
| Gross area | 2.224 m ² |
| Aperture area | 1.962 m ² |
| Absorber area | 2.559 m ² |
| Weight empty | 49.0 kg |
| Fluid capacity | 2.4 l |

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

| Construction | |
|--|--------------------------|
| Type | Evacuated tube collector |
| Number of absorber elements | 10 |
| Absorber pitch | 110.0 mm |
| Number of hydraulically parallel tubes | 10 |
| Number of thermally serial glazings | 1 |
| Material of glazing(s) | Borosilicate glass |
| Thickness of glazing(s) | 2.2 mm |

| Casing and insulation | |
|-----------------------|------------------------------|
| Casing material | Aluminium |
| Sealing material | Silicone |
| Insulation material | Rockwool compression-moulded |
| Thickness (in mm) | 30 |
| Aperture dimensions | 1.733 m * 1.132 m |

| Limitations (manufacturer information) | |
|--|---------------|
| Max. temperature | Not specified |
| Max. operating pressure | 6 bar |
| Other | -- |

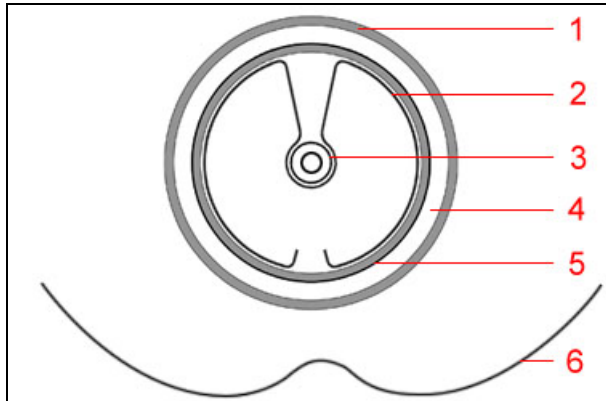
| Heat transfer fluid (manufacturers' recommendation) | |
|---|-----------------------|
| Type | Water-Propyleneglycol |
| Specifications | -- |

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

| Flow range (manufacturers' recommendation) | |
|--|--------------|
| Flow range | 60 - 180 l/h |
| Rated flow rate | 120 l/h |

| Test schedule | |
|-----------------|----------------------------|
| Test procedure | EN12975:2006, Outdoor test |
| Sample received | 08.02.2011 |
| Start of test | 01.04.2011 |
| End of test | 21.06.2011 |

1.2 Sketch of Collector



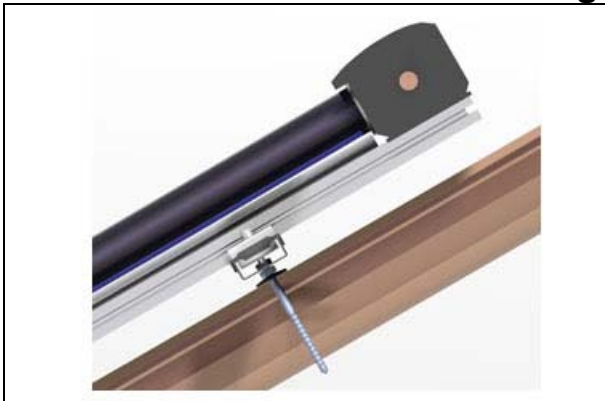
1.3 Specifications on Elements

| | | |
|----------|--|--|
| 1 | Glazing Material: Thickness [mm]: | Borosilicate glass 2.2 |
| 2 | Heat-conducting metal sheet Description: | Aluminum |
| 3 | Coaxial tube Description: | Copper |
| 4 | Vacuum | |
| 5 | Absorber Absorber element: Flow-through element: Length of element [mm]: Width of element [mm]: Flow type: | Evacuated double glass tube Coaxial copper pipe 1741 47 Parallel |
| 5 | Absorber coating Description: | Cr-Al-N/Cu |
| 6 | CPC reflector Description: | Aluminum |

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

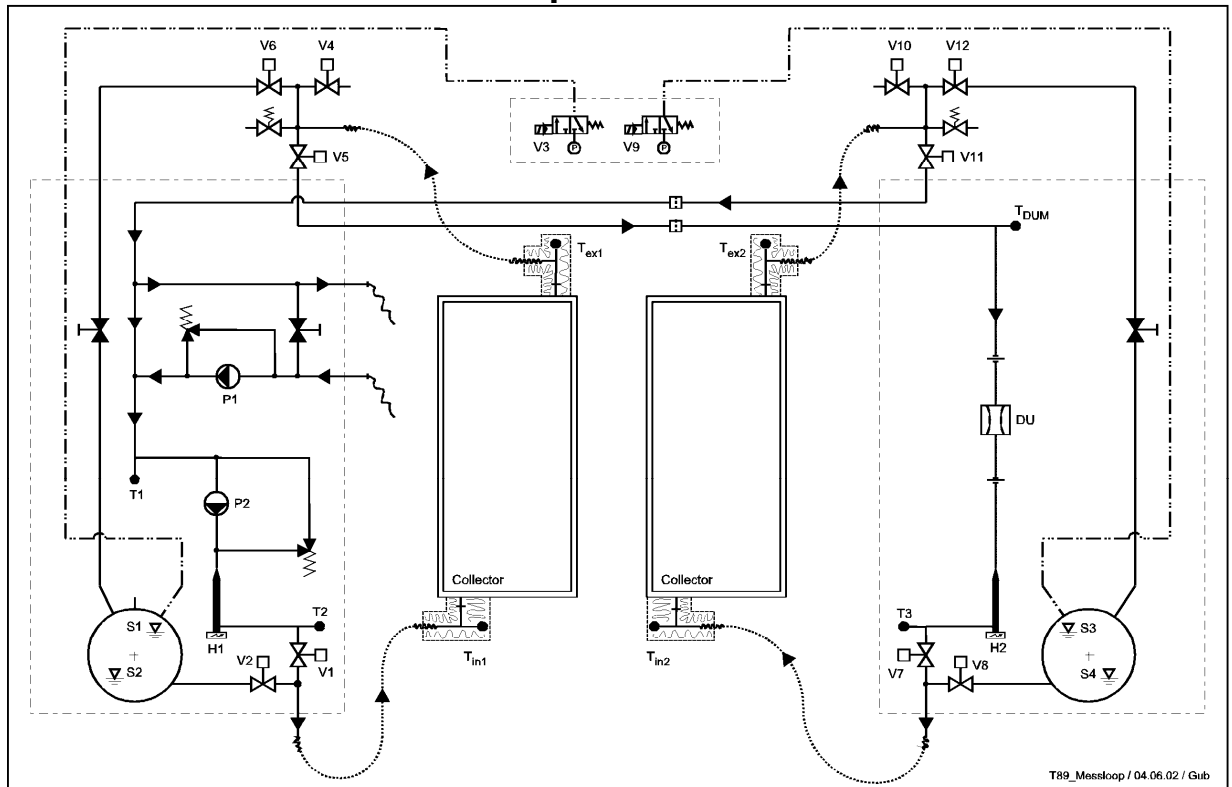


Fig. 2.1: Test loop for efficiency measurements.

2.3 Power Output

2.3.1 General

| | |
|--|--|
| Flow rate during test | 140.0 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} .

$$W_{\text{peak}} = 1282 \text{ [W]}$$

2.3.2.2 Diagram

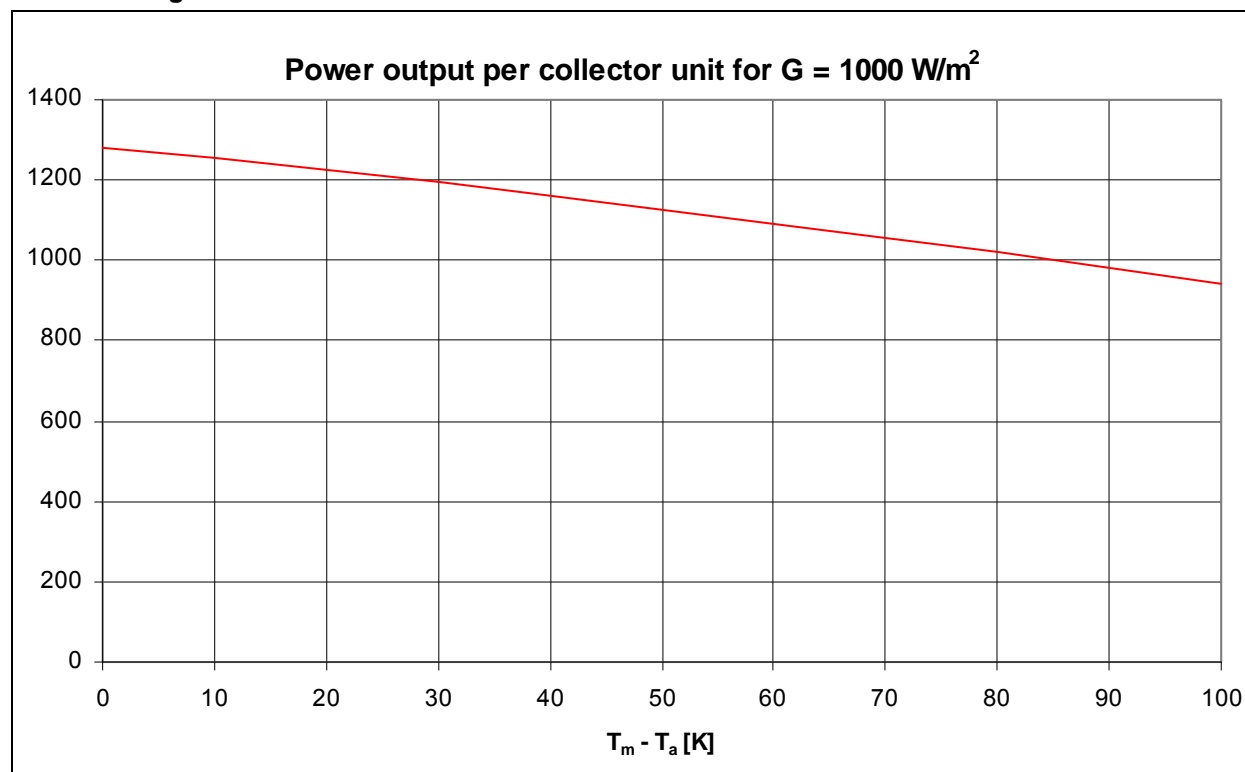


Fig. 2.2: Power output per collector unit at irradiance $G = 1000 \text{ W/m}^2$

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 | 485 W | 869 W | 1254 W |
| 30 K | 424 W | 809 W | 1193 W |
| 50 K | 359 W | 743 W | 1128 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.

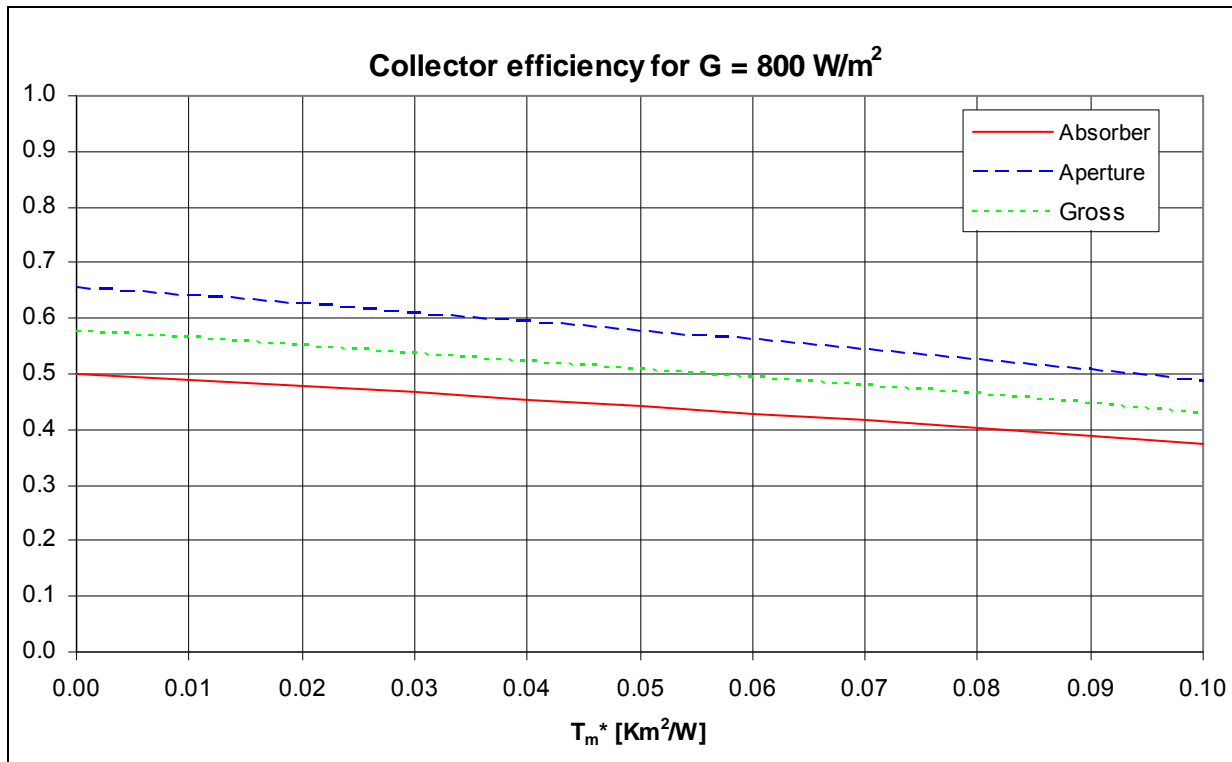


Fig. 2.3: Efficiency diagram for $G = 800 \text{ W/m}^2$

2.3.3.1 Parameters for efficiency equation

| Reference area | Absorber area | Aperture area | Gross area |
|------------------------------------|---------------|---------------|------------|
| η_0 (-) | 0.501 | 0.653 | 0.576 |
| a_1 ($\text{W/m}^2\text{K}$) | 1.08 | 1.41 | 1.24 |
| a_2 ($\text{W/m}^2\text{K}^2$) | 0.0025 | 0.0033 | 0.0029 |

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 | 0.94 | 0.87 | 0.73 | 0.48 | 0.00 |
| K_{Θ} (transversal) | 1.00 | 0.99 | 0.98 | 0.98 | 1.02 | 1.11 | 1.15 | 1.07 | 0.64 | 0.00 |

2.4.2 Diagram of the Incidence Angle Modifier

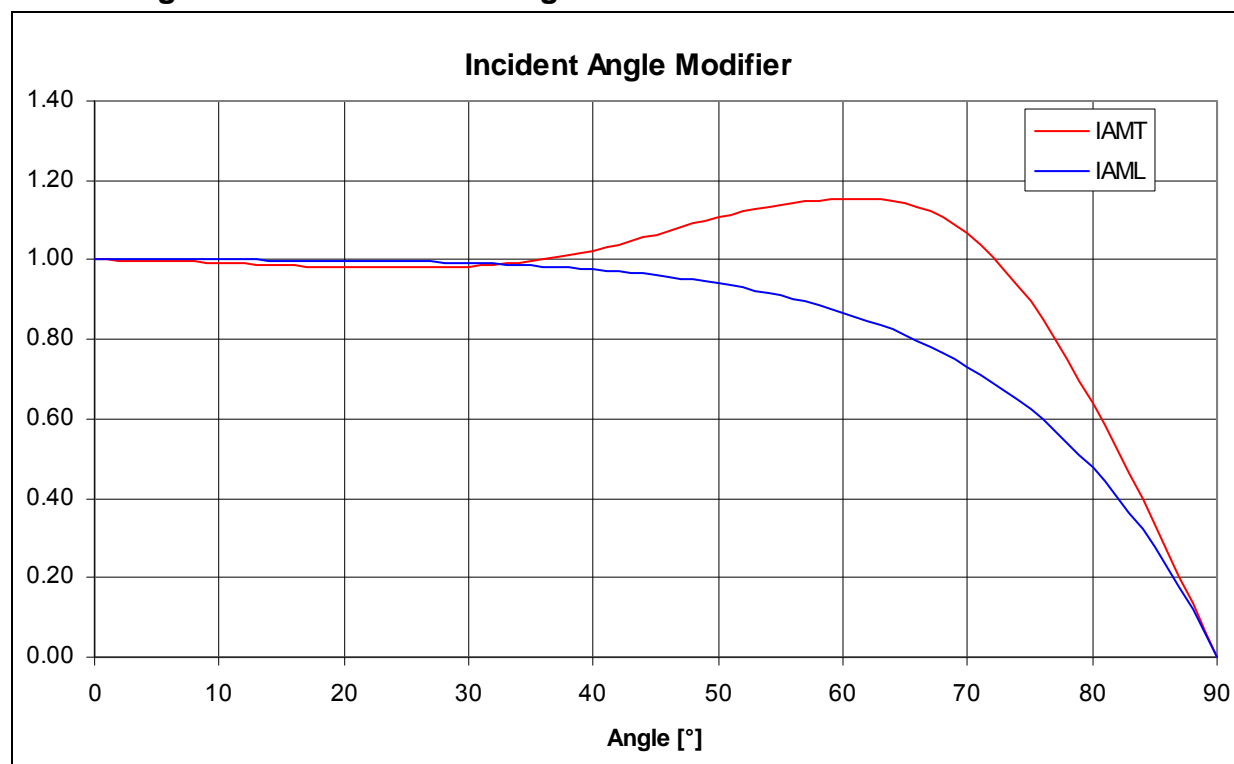


Fig. 2.4: Incident angle modifiers

2.5 Time Constant

$$\tau_C = 502 \text{ s}$$

2.6 Effective Thermal Capacity

2.6.1 Determination according to EN12975-2:2006, Annex G3

Determination based on transient behaviour of the collector.

$$C_{\text{eff,G3}} = 135.4 \text{ kJ/K (Effective thermal capacity of collector filled with fluid)}$$

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

$$C_{\text{eff,G3}} = 2.4 \text{ l} * \text{density} * \text{specific heat capacity of fluid} + 126.3 \text{ kJ/K}$$

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

Estimation based on material properties.

$$C_{\text{eff,G162}} = 24.3 \text{ kJ/K (Effective thermal capacity of collector filled with fluid)}$$

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

$$C_{\text{eff,G162}} = 2.4 \text{ l} * \text{density} * \text{specific heat capacity of fluid} + 15.2 \text{ kJ/K}$$

2.7 Pressure Drop

2.7.1 Diagram

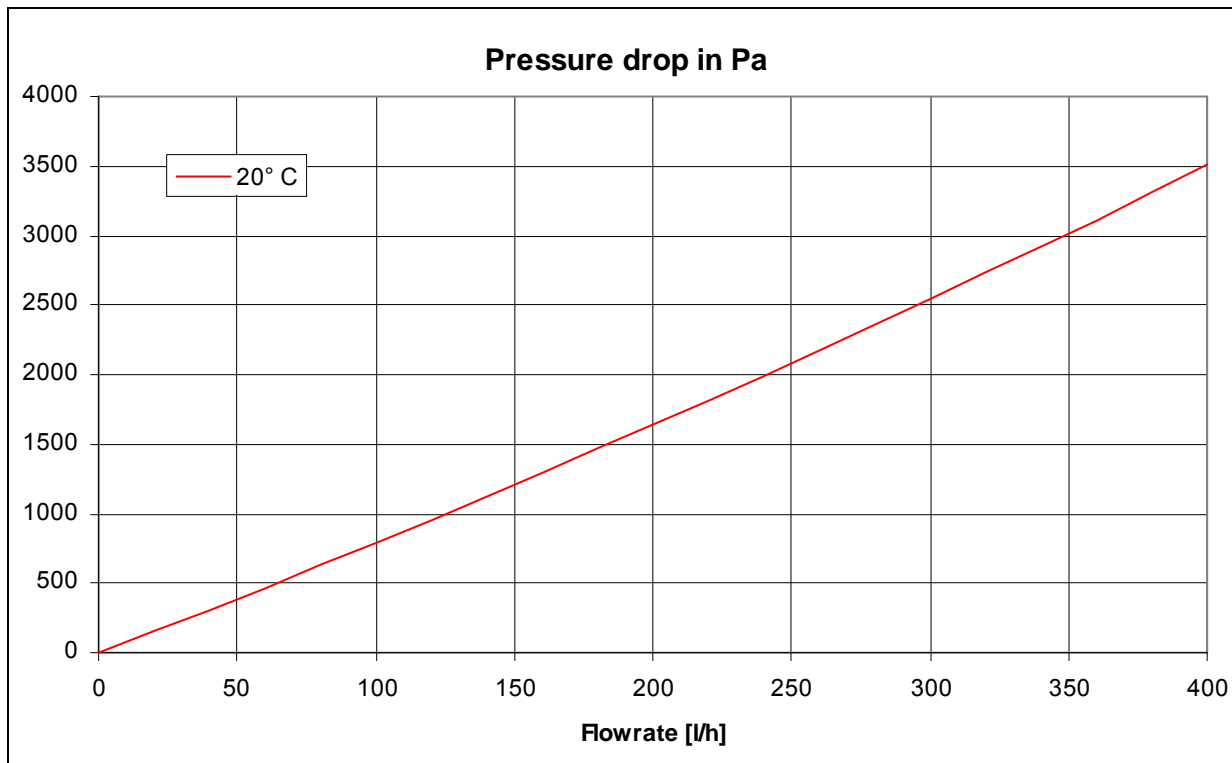


Fig. 2.5: Pressure drop as a function of volume flowrate

2.7.2 Pressure drop at rated flowrate

Conditions:

$T_m = 20^\circ\text{C}$ and $dV/dt = 120 \text{ l/h}$

$\Delta p = 955 \text{ Pa}$

2.7.3 Table of pressure drop data in Pa

Conditions:

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

| Flow rate [l/h] | 0 | 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 |
|--------------------|---|-----|-----|------|------|------|------|------|------|
| Pressure drop [Pa] | 0 | 388 | 790 | 1206 | 1637 | 2082 | 2542 | 3016 | 3504 |

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, 08.08.2011



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