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TEST OF SOLKIT SOLAR COLLECTOR

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The dimensions of the tested Solkit solar collector are given in table 1.

Outer dimensions:	3.005 m x 1.600 m x 0.125 m
Weight (empty):	114 kg
Solar collector fluid volume:	1.5 l
Gross area:	4.81 m^2
Aperture area:	4.36 m^2

Table 1. Dimensions of the tested solar collector.

The solar collector was tested according to [1] in the laboratory's solar simulator test facility [2]. Figure 1 shows a photo of the solar collector in the test facility. The solar collector fluid used in the tests was a 33% ethylene glucol/water mixture.

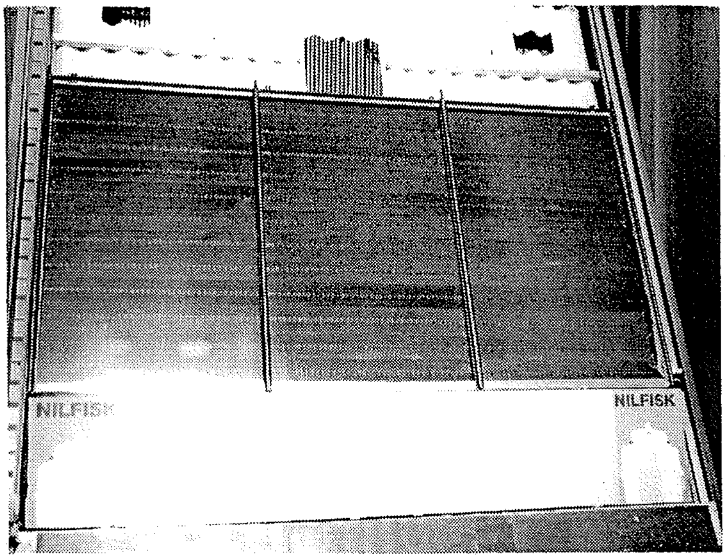

Figure 1. Tested solar collector.

The measured efficiencies based on the aperture area at a mass flow rate of about 0.05 kg/s corresponding to about 0.011 kg/s per m^2 solar collector are given in table 2. The used flow rate is somewhat smaller than the flow rate used for standard tests of solar collectors.

Irradiance G W/m²	Mass flow rate kg/s	Ambient air temperature T_{amb} °C	Inlet temperature $T_{coll,in}$ °C	Temperature difference across the colletor $\Delta T = T_{coll,out} - T_{coll,in}$ K	Efficiency η
903	0.0497	29.0	26.4	16.37	0.758
	0.0496	28.9	26.4	16.43	0.759
	0.0497	28.9	26.4	16.36	0.758
	0.0497	29.0	26.4	16.28	0.754
907	0.0498	27.2	45.1	14.00	0.654
	0.0494	27.2	45.1	14.07	0.652
	0.0491	27.2	45.1	14.15	0.652
	0.0492	27.2	45.1	14.13	0.653
908	0.0497	28.4	73.1	10.75	0.510
	0.0497	28.4	73.1	10.74	0.509
	0.0495	28.4	73.1	10.76	0.508
	0.0497	28.4	73.1	10.72	0.509
889	0.0490	28.3	89.9	8.33	0.402
	0.0493	28.3	89.9	8.34	0.405
	0.0491	28.3	89.9	8.36	0.404
	0.0491	28.3	89.9	8.30	0.401

Table 2. Measured efficiencies with a collector tilt of 67.5° and a wind speed along the collector of 5 m/s. The efficiencies are based on the solar collector aperture area 4.36 m².

The results are summarized in such a way that the efficiency of the solar collector with a tilt of 67.5° is determined by means of the equation:

$$\eta = 0.79 - 4.61 \times T^* - 0.009 * G * (T^*)^2,$$

where $T^* = ((T_{coll,in} + T_{coll,out})/2 - T_{amb})/G$.

The measured heat loss coefficient of the solar collector for different collector tilts are given in table 3. The measurements can be summarized in such a way that ks, the heat loss coefficient of the collector with a collector tilt s from horizontal, can be determined from the equation:

$$ks/k_{45°} = 1.0358 - 0.00079 \times s$$

Solar collector tilt from horizontal °	Mass flow rate kg/s	Ambient air temperature T_{amb} °C	Inlet temperature $T_{coll,in}$ °C	Temperature difference across the collector $\Delta T = T_{coll,in} - T_{coll,out}$ K	Heat loss coefficient k W/m^2K
67.5	0.0497 0.0500 0.0498 0.0497	22.1 21.9 22.1 22.3	73.0 73.0 73.0 73.0	5.05 5.03 5.04 5.04	4.47 4.46 4.46 4.48
45	0.0497 0.0499 0.0497 0.0497	22.9 23.0 22.9 23.0	73.0 73.0 73.0 73.1	5.04 5.02 5.03 5.03	4.53 4.54 4.52 4.53
22.5	0.0501 0.0502 0.0502 0.0503	23.3 23.3 23.2 23.3	73.1 73.1 73.1 73.1	5.07 5.06 5.06 5.05	4.63 4.63 4.62 4.64

Table 3. Measured heat loss coefficients with a wind speed along the collector of 5 m/s. The heat loss coefficients are based on the solar collector aperture area 4.36 m².

Based on the measurements the efficiency of the collector is thus found by means of the equation:

$$\eta = 0.79 - 4.69 \times T^* - 0.009 \times G \times (T^*)^2$$

where $T^* = ((T_{coll,in} + T_{coll,out})/2 - T_{amb})/G$

The assumptions for this equation:

- the efficiency is based on the aperture area of 4.36 m².
- the solar collector tilt is 45°.
- the solar radiation consists only of direct irradiance.
- the angle of incidence is smaller than 30°.
- the wind speed along the solar collector is 5 m/s.
- the solar collector fluid is a 33% ethylene glucol/water mixture.
- the mass flow rate is about 0.011 kg/s per m² solar collector.

The efficiencies corresponding to the above mentioned equation for a solar irradiance of 800 W/m² are shown in figure 2.

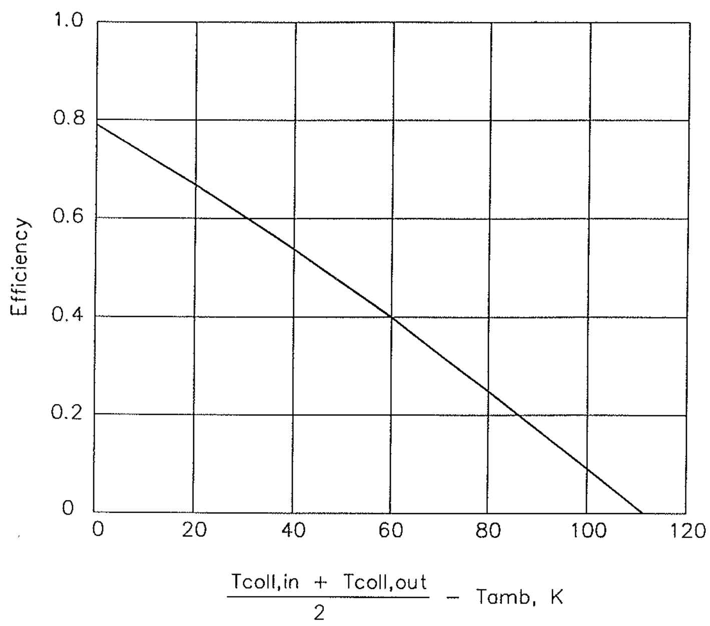

Figure 2. Collector efficiency at a solar irradiance of 800 W/m² and a collector tilt of 45°.

The collector efficiency was measured for three additional smaller flow rates. The results of these measurements are shown in table 4.

Irradiance G W/m²	Mass flow rate kg/s	Ambient air temperature T_{amb} °C	Inlet temperature $T_{coll,in}$ °C	Temperature difference across the colletor $\Delta T = T_{coll,out} - T_{coll,in}$ K	Efficiency η
897	0.0427	28.4	25.7	18.68	0.748
	0.0426	28.4	25.7	18.76	0.751
	0.0426	28.4	25.7	18.79	0.751
	0.0427	28.5	25.7	18.78	0.752
900	0.0218	30.0	26.6	33.71	0.690
	0.0218	30.0	26.6	33.75	0.691
	0.0218	29.9	26.6	33.79	0.692
	0.0218	30.1	26.6	33.76	0.691
897	0.0109	28.8	26.5	57.43	0.594
	0.0109	28.9	26.6	57.48	0.594
	0.0109	28.9	26.5	57.53	0.595
	0.0109	29.0	26.5	57.49	0.594

Table 4. Measured efficiencies with a collector tilt of 67.5° and a wind speed along the collector of 5 m/s. The efficiencies are based on the solar collector aperture area 4.36 m².

The results are normally presented by means of F_f, a correction factor for the flow rate. F_f is defined as the ratio between the solar collector efficiency at a low flow rate and the solar collector efficiency at the standard flow rate at the same conditions, that is the same mean fluid temperature in the solar collector and the same solar irradiance:

$$F_f = \frac{\eta_{\text{low flow}}}{\eta_{\text{standard flow}}}$$

The method used to determine F_f by means of the measurements is described in [3]. The Solkit collector was tested at a flow rate of 0.65 l/min per m² solar collector and it was not tested at the normal standard flow rate of 1.2 l/min per m² solar collector. Consequently, F_f is for this collector determined as the ratio between the efficiency at a low flow rate and the efficiency at a flow rate of 0.65 l/min per m² solar collector. The quantities of F_f found by the tests are given in table 5.

Flow rate			Integrated mean fluid temperature T_m	T_m-T_{amb}	η	F_f
kg/s	kg/s m² collector	l/min m² collector	°C	K		
0.0427	0.0098	0.56	35.3	6.9	0.751	1.01
0.0218	0.0050	0.29	44.2	14.2	0.691	0.98
0.0109	0.0025	0.14	57.7	28.8	0.594	0.96

Table 5. F_f for small flow rates with a collector tilt of 67.5° and a wind speed along the collector of 5 m/s.

The pressure loss across the solar collector was measured with water as the solar collector fluid at 26°C for different flow rates. The results of these measurements are summarized in figure 3, which shows the pressure loss across the solar collector with water as the solar collector fluid as a function of the flow rate.

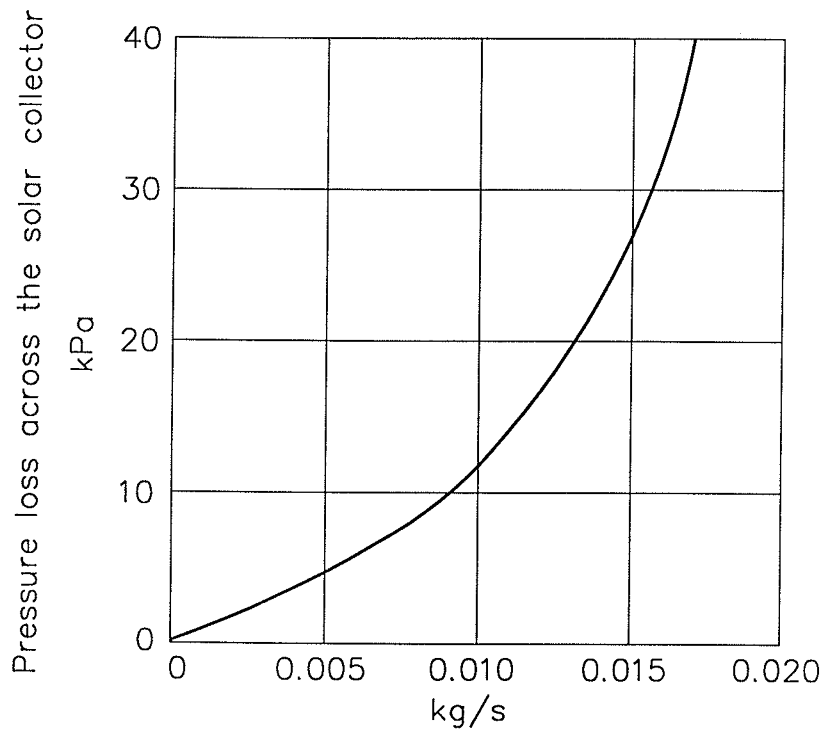

Figure 3. **Measured pressure loss across the solar collector with water as the solar collector fluid at 26°C as a function of the mass flow rate.**

REFERENCES

[1] "Solar Collectors - Part 1: Methods of Test for the Thermal Performance of Liquid Heating Collectors". ISO/DIS 9806-1, International Organization for Standardization, 1991.

[2] "Solar Simulator Test Facility". S. Svendsen, Thermal Insulation Laboratory. From Proceedings: "North Sun '92 Solar Energy at High Latitudes". Trondheim, Norway, June 1992.

[3] "Low Flow Test Procedure and Results". S. Svendsen, Thermal Insulation Laboratory, Technical University of Denmark. Report no. 92-22, August 1992.