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AUSTRIAN INSTITUTE OF TECHNOLOGY

Test Report

Project Designation

Durability and reliability test of a covered solar collector according to ÖNORM EN 12975-1 and 2

Client

GASOKOL GmbH
Markt 53
A-4371 Dimbach

Order from / No. 11 April 2005

Project No. 2.04.00327.1.0 Test Engineer Thomas Huger

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Number of Pages	18
Annex: number of pages	-

Durability and reliability test of a covered solar collector in new condition according to ÖNORM EN 12975-1 and 2

Test center:
ÖSTERREICHISCHES FORSCHUNGS- UND PRÜFZENTRUM ARSENAL Ges.m.b.H

Test number: 2.04.00327.1.0
Client: GASOKOL GmbH
Receipt of test sample: 31.03. 2005
Test period: from 19.04.2005 to 09.06.2005

1. MEASURING INSTRUMENTS USED

1.1. Measuring instruments

1 x Pyranometer Kipp & Zonen Type CM11, device No. 945367, Sensitivity: $4{,}77 \times 10^{-6}$ [V/Wm^{-2}]
1 x Temperature measuring sensor Fluke 51 K/J, ÖKD measurement uncertainty $\pm$ 0,1 K
1 x Scale, Jadever JPS 2030, device No. 40003617, DKD measurement uncertainty $\pm$ 0,05 Kg
1 x Digital spring balance MWT, type 120E/500-5000, device No.120530,
expanded measurement uncertainty U = 848,5281 g + 0,0036955 * m_W
1 x Manometer, Wika, 0-16 bar, ser. No. 114.43.73, ÖKD measurement uncertainty $\pm$ 0,077 bar
1 x Variable area float meter, Krohne VA 20/R 100 - 1000 l/h,
calibrated according VDI/VDE 3513, accuracy class 1,0
1 x Pt-100 temperature measurement sensor for measuring the ambient air temperature,
ÖKD measurement uncertainty $\pm$ 0,05 K
1 x Rain sensor, Conrad, device No.115274
1 x VAISALA Humidity Transmitter HMD 30UB
ÖKD temperature measurement uncertainty $\pm$ 0,1 K
ÖKD humidity measurement uncertainty $\pm$ 2,0 % r.F.
1 x Tape measure, Convex-Stop, JIS 1 OC 16-55, calibrated,
expanded measurement uncertainty U = 0,3 mm

1.2. Data acquisition

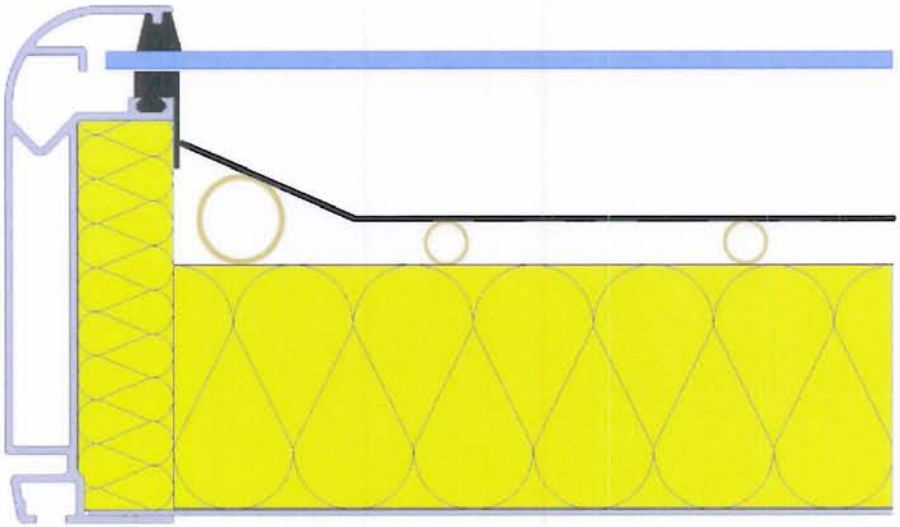
1 x Data acquisition unit, Hydra 2635A Data Bucket 3625A, ser. No. 610 1307,
ÖKD measurement uncertainty DCV 0,04 %
ÖKD measurement uncertainty ACV 0,02 %
ÖKD measurement uncertainty DCA-resistance 0,30 %

2. GENERAL SPECIFICATIONS OF THE TESTED COLLECTOR

Manufacturer of the collector:	Gasokol GmbH
Distributed by:	Gasokol GmbH Markt 53 A-4371 Dimbach
Collector type and name:	inSpire (flat plate collector)
Measurements (without pipe connection):	2100 mm x 1070 mm x 105 mm
Heat transfer fluid content:	*) 1,95 l
Maximum operation pressure:	*) 6 bar
Type of collector cover:	*) ESG-Solar glass, τ = 0.89,
Structure of the absorber:	absorber sheet Cu 0.2 mm, soldered, harp connection with 8 parallel pipes (size 8 x 0,5) and collecting pipe (size 22 x 1)
Absorber coating:	*) sputtered, absorptance α = 0,95 emittance ε = 0,05
Collector insulation:	back side, 50 mm mineral wool (50 kgm^{-3}), Side wall, 20 mm mineral wool (105 kgm^{-3}) coated with black glass fleece
Collector frame:	*) aluminium
Collector back side:	*) aluminium
Sealing material:	*) EPDM
Recommended heat transfer fluid:	water / propylene glycol solution (60:40)

*) specifications with this sign are manufacture's instructions

Schematic diagram of solar collector (according to the client's information)



Photograph of solar collector:

3. TEST PROCEDURE

The collector was tested, according to ÖNORM EN 12975-2.

The following tests were made
(The real order of tests depends on the external climatic and meteorological conditions)

1. Internal pressure for absorber (1)
2. High temperature resistance
3. Exposure test
4. External thermal shock (2x)
5. Internal thermal shock (2x)
6. Rain penetration test
7. Internal pressure of absorber (2)
8. Mechanical load test
9. Final inspection

3.1. Internal pressure for absorber (1)

The tested product is a covered frame collector. The maximum operation pressure, according to the manufacturer, is 6 bar.

3.1.1. Method

Load test with a 1,5 times higher pressure then operation pressure.

3.1.2. Test conditions

The collector is mounted horizontally

Ambient air temperature:	18,1 °C
Test pressure:	920 k Pa
Test duration:	15 min
Heat transfer fluid:	water

3.1.3. Result

No visible changes

3.2. High temperature resistance

3.2.1. Method

At the outdoor test und natural solar radiation

3.2.2. Test condition

Collector tilt angle	40,5 °
Average hemispherical solar irradiance during testing	1019,9 Wm^{-2}
Average ambient air temperature	15,7 °C
Average ambient air velocity	< 1 ms^{-1}
Average temperature of the absorber	188,1 °C
Duration of test	60 min

The absorber sensor was mounted on 2/3 of the height and half of the width of the absorber.

3.2.3. Result

No visible changes were realized

3.3. Exposure test

3.3.1. Method

The long-term-test was performed in the period from 24 April 2005 to 05 June 2005 at the outdoor test track of arsenal research. The collector was mounted on fix standing frame.

3.3.2. Test conditions

date	hours with I> 850 Wm^{-2}	hemispherical solar irradiance [MJm^{-2}]	ambient temperature (average) [°C]	rain	relevant days
24.04.2005	3,5	20,91	14,55	no	1
27.04.2005	1,0	16,31	16,24	no	2
28.04.2005	1,5	19,15	14,56	no	3
29.04.2005	4,5	27,02	15,03	no	4
30.04.2005	3,0	22,29	17,80	no	5
01.05.2005	4,5	25,84	20,62	no	6
02.05.2005	3,5	26,28	24,94	yes	7
03.05.2005	1,0	17,20	23,59	yes	8
05.05.2005	1,5	16,68	14,36	yes	9
06.05.2005	0,5	14,29	11,13	no	10
13.05.2005	4,5	28,72	15,30	no	11
14.05.2005	0,5	19,54	17,28	no	12
15.05.2005	2,5	19,59	18,20	no	13
16.05.2005	1,5	17,95	17,33	no	14
20.05.2005	4,5	29,02	14,83	no	15
21.05.2005	4,0	28,08	19,42	no	16
22.05.2005	3,0	25,19	20,93	no	17
23.05.2005	1,5	21,44	21,83	yes	18
24.05.2005	1,5	19,41	17,17	no	19
25.05.2005	4,5	28,93	19,48	no	20
26.05.2005	5,0	29,93	22,24	no	21
27.05.2005	4,5	29,60	25,29	no	22
28.05.2005	4,5	29,29	26,59	no	23
29.05.2005	4,5	28,70	28,75	no	24
30.05.2005	3,5	21,90	27,14	yes	25
31.05.2005	1,0	16,18	16,32	no	26
01.06.2005	2,0	20,08	16,84	no	27
02.06.2005	4,5	27,85	19,55	no	28
03.06.2005	4,5	28,86	22,55	no	29
04.06.2005	0,5	14,99	19,83	yes	30
05.06.2005	2,0	21,28	18,26	yes	31

3.3.3. Result

No appreciable changes.

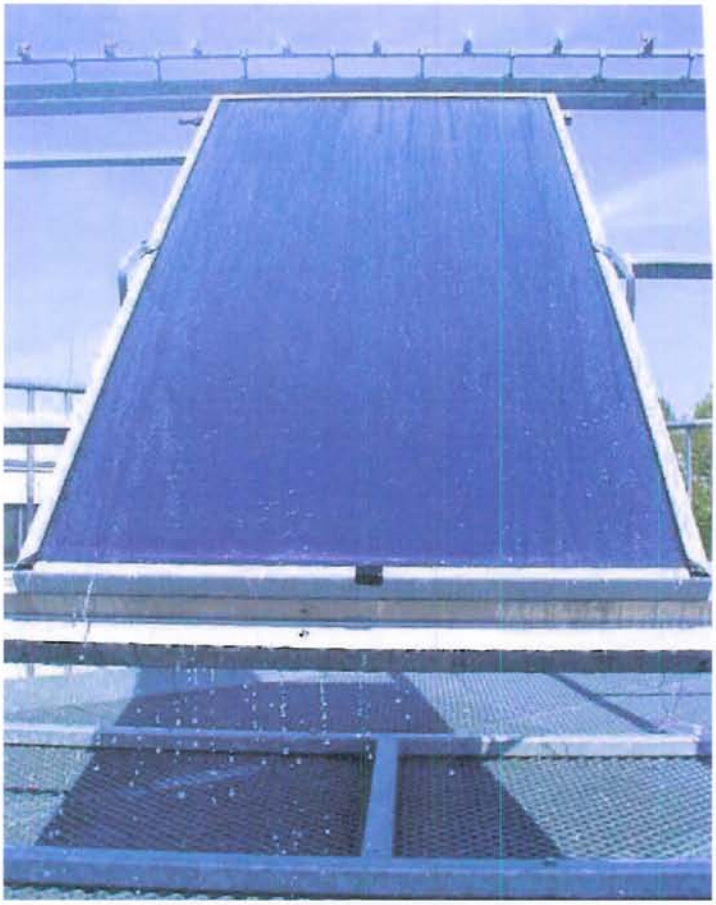
3.4. External thermal shock

3.4.1. Method

Outdoor test; flat plate collector; therefore additional specifications concerning tests of vacuum tube collectors are void.

3.4.2. Test conditions

Shock No.	1	2
Warm up phase:		
Collector tilt angel	40,5 °	29 °
Average hemispherical solar irradiance	914 Wm^{-2}	905 Wm^{-2}
Minimum hemispherical solar irradiance	851 Wm^{-2}	840 Wm^{-2}
Average ambient air temperature	26,4 °C	30,2 °C
Time of steady state before shock	> 60 min	> 60 min
Shock:		
Average hemispherical solar irradiance	945 Wm^{-2}	958 Wm^{-2}
Minimum hemispherical solar irradiance	841 Wm^{-2}	936 Wm^{-2}
Average ambient air temperature	27,6 °C	31,2 °C
Amount of spraying	>0,04 $kgs^{-1}m^{-2}$	>0,04 $kgs^{-1}m^{-2}$
Water temperature	20,3 °C	18,0 °C
Irrigation time	20 min	20 min
Test combined with long-time-test	yes	yes
Test combined with high temperature resistance	no	no



3.4.3. Result

No visible changes

3.5. Internal thermal shock

3.5.1. Method

Outdoor test; flat plate collector; therefore additional specifications concerning tests of vacuum tube collectors are void.

3.5.2. Testbedingungen

Shock No.	1	2
Warm up phase:		
Collector tilt angel	40,5 °	29 °
Average hemispherical solar irradiance	995 Wm^{-2}	950 Wm^{-2}
Minimum hemispherical solar irradiance	918 Wm^{-2}	917 Wm^{-2}
Average ambient air temperature	28,0 °C	33,4 °C
Time of steady state before shock	> 60 min	> 60 min
Shock:		
Average hemispherical solar irradiance	919 Wm^{-2}	911 Wm^{-2}
Minimum hemispherical solar irradiance	869 Wm^{-2}	904 Wm^{-2}
Average ambient air temperature	28,6 °C	34,5 °C
Flow rate	>0,02 $kgs^{-1}m^{-2}$	>0,02 $kgs^{-1}m^{-2}$
Water temperature	14,4 °C	15,2 °C
Time of flow	7 min	7 min
Test kombiniert mit Langzeittest	yes	yes
Test kombiniert mit Hochtemperaturbeständigkeitstest	no	no

3.5.3. Result

No visible changes

3.6. Rain penetration test

3.6.1. Method

Outdoor test, the collector is mounted on an open frame with a tilt angle of 29°.
The absorber is pressurised with hot water (at least 50°C). Rain is simulated with pivoted spray nozzles. The spraying happened all over the collector.

3.6.2. Identifikation of leakages

The identification of potential leakages:
a) By measurement of humidity inside the collector and
b) By inspection

3.6.3. Test conditions

Spraying during a period of 4 hours with more than 0,05 $kgs^{-1}m^{-2}$ flow rate and a water temperature of 17,2 °C.

3.6.4. Result

a) Measurement of humidity inside the collector:

Absolute humidity x before spraying	10,3 gH_2O / kg air
Absolute humidity x after spraying	10,9 gH_2O / kg air

b) Inspection:

No penetration of water visible.

3.6.5. Judgement

No penetration of water and no significant increase of absolute humidity.

3.7. Internal pressure test (2)

The tested product is a covered frame collector. The maximum operation pressure, according to the manufacturer, is 6 bar. After passing minimum loading test, pressure is increased.

3.7.1. Method

Load test with a 1,5 times higher pressure the maximum operation pressure.

3.7.2. Test conditions

The collector is mounted horizontally.

Ambient air temperature:	19,6 °C
Test pressure:	920 / 1520 k Pa
Test duration:	15 min
Heat transfer fluid:	water

3.7.3. Result

No visible changes even while increased pressure.

3.8. Mechanical load test

3.8.1 Positive pressure test of the collector cover

3.8.1.1. Method

The collector cover is loaded step by step up to an area load of 1000 Pa by means of a mechanical device.

3.8.1.2. Test conditions

Position of the collector: horizontally; the collector is mounted on a frame. The load increases in steps by 100 Pa up to a maximum of 1000 Pa.

3.8.1.3. Results

No visible damage has to be reported up to the maximum load.

3.8.2. Negative pressure test of the collector cover

3.8.2.1. Method

The collector cover is loaded step by step up to an area load of 1000 Pa with a tensile testing facility.

3.8.2.2. Test conditions

Position of the collector: horizontally; the collector is mounted on a frame. The load increases in steps by 100 Pa up to a maximum of 1000 Pa.

3.8.2.3. Result

Up to the maximum load the collector cover takes off slightly. However if the load decreases the collector cover is laying in the original position. No visible damage up to the maximum load.

3.8.3. Negative pressure test of the collector mounting

3.8.3.1. Method

While the cover is loaded the same load is on the collector mounting

3.8.3.2. Test conditions

Two mounting sets were tested:

- On-roof mounting set with hanger bolts
- On-roof mounting set for brick roof

Position of the collector: horizontally; the collector is mounted on a frame. The load increases in steps by 100 Pa up to a maximum of 1000 Pa.

3.8.3.3. Result: on-roof mounting set with hanger bolts

See: 3.8.2.3.

3.8.3.4. Result: on-roof mounting set for brick roof

Up to the maximum load the mounting brackets take off considerably. However if the load decreases the brackets are laying in their original position. No visible damage up to the maximum load.

3.9. Final inspection

3.9.1. Monitoring / documentation

Photo: opened collector

Cover of the lower edge of collector with silicone

2 ventilation slits, side / top (12 x 3 mm)
2 ventilation slits, lower edge (18,5 x 5 mm)

Photo: Lower edge with mounting brackets

Photo: Lateral ventilation slits

Inside edges soldered, back side and corners with silicone sealed

Photo: Border insulation

Photo: Inside edges

Photo: back side with silicone

No considerable observations.

3.9.2. Appraisal of results

0 - No problem

1 - Marginal problem

2 - Serious problem

° - Inspection was impossible

Components	Possible problems	Appraisal
1. collector box	breakage, bendings, corrosion, penetration of water	0
2. fixings/glass holder	fatigue of material/security	0
3. seals	breakage, adhesion, elasticity	0
4. covers/reflector	breakage, tearing, lumps, dissolution, creation of perspiration water	0
5. absorber coating	breakage, tearing, lumps,	0
6. absorber tube, distributor tube and header	deformation, corrosion, leakage, solve the connection	0
7. absorber mounting	deformation, corrosion	0
8. thermal insulation	water absorption, fumigation, degradation	0

3.10. Summary

Client	GASOKOL GmbH
Address	Markt 53, A-4371 Dimbach
Telephone and fax	Tel. +43/7260/7475-0 Fax: +43/7260/7475-4

Test report No. – date of issue	2.04.00327.1.0 vom 13.06.2005
Year of production	2005
Collector type / name	Flat plate collector / inSpire
Serial number	200519-7

Test	Test start	Test end	Passed
1. Internal pressure test (1)	19.04.2005	19.04.2005	YES
2. High temperature resistance	23.04.2005	23.04.2005	YES
3. Exposure rest	24.04.2005	05.06.2005	YES
4. External thermal shock (2x)	02.05.05/30.05.05	02.05.05/30.05.05	YES
5. Internal thermal shock (2x)	02.05.05/30.05.05	02.05.05/30.05.05	YES
6. Rain penetration test	07.06.2005	07.06.2005	YES
7. Internal pressure test (2)	08.06.2005	08.06.2005	YES
8. Mechanical load Test	08.06.2005	09.06.2005	YES
9. Final inspection	09.06.2005	09.06.2005	YES

The test results are only valid for the collector which was tested.

The collector which is mentioned above has passed the durability and reliability test according to EN 12975-1 and 2.

Signatory

Ing. Heinrich Huber, Msc.

Österreichisches Forschungs- u. Prüfzentrum Arsenal GmbH • vom BMwA akkreditierte Prüfstelle

Project manager

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