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ISFH CalTeC

Annex to Solar Keymark Certificate		Licence Number	**011-7S3009 R**
		Date issued	**2021-06-24**
		Issued by	**ISFH CalTeC**
Licence holder	**AKOTEC Produktionsgesellschaft**	**Country**	Germany
Brand (optional)		**Web**	http://www.akotec.eu
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Collector Type	Evacuated tubular collector

Collector name	Gross area (A_G)	Gross length	Gross width	Gross height	Power output per collector, Gb = 850 W/m2, Gd = 150 W/m2 & u = 1.3 m/s, $\vartheta_m - \vartheta_a$: 0 K	10 K	30 K	50 K	70 K	90 K
	m²	mm	mm	mm	W	W	W	W	W	W
Weiser Protect 800[1)]	1.61	2 159	745	128	701	678	627	569	504	432
Weiser Protect 1600[1)]	3.23	2 159	1 495	128	1 407	1 361	1 257	1 141	1 012	869
Weiser Protect 2400[1)]	4.85	2 159	2 245	128	2 113	2 043	1 888	1 713	1 520	1 305
lowest switching temperature[2)]**:**										
Weiser Protect 800[2)]	1.61	2 159	745	128	701	678	627	*539*	*321*	*103*
Weiser Protect 1600[2)]	3.23	2 159	1 495	128	1 407	1 361	1 257	*1 083*	*645*	*207*
Weiser Protect 2400[2)]	4.85	2 159	2 245	128	2 113	2 043	1 888	*1 626*	*968*	*310*
per m², lowest switching temp.[2)]	1.00				436	422	390	*335*	*200*	*64*
Power output per m² gross area					436	422	390	354	314	269

Performance parameters test method	Steady state - indoor									
Performance parameters (related to A_G)	η0, b	a1	a2	a3	a4	a5	a6	a7	a8	Kd
Units	-	W/(m²K)	W/(m²K²)	J/(m³K)	-	J/(m²K)	s/m	W/(m²K⁴)	W/(m²K⁴)	-
Test results	0.444	1.40	0.005			2 724				0.88

Incidence angle modifier test method	Quasi dynamic - outdoor								
Incidence angle modifier	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
Transversal	$K_{\theta T,coll}$	1.01	1.02	1.03	1.04	1.07	1.08	0.83	0.42	0.00
Longitudinal	$K_{\theta L,coll}$	1.00	0.99	0.98	0.96	0.93	0.87	0.75	0.47	0.00

Heat transfer medium for testing	Water		
Flow rate for testing (per gross area, A_G)	dm/dt	0.021	kg/(sm²)
Maximum temperature difference during thermal performance test	$(\vartheta_m - \vartheta_a)_{max}$	132	K
Standard stagnation temperature (G = 1000 W/m²; ϑ_a = 30 °C)	ϑ_{stg}	170/130	°C (comments)
Maximum operating temperature	$\vartheta_{max\ op}$	100	°C
Maximum operating pressure	$p_{max,op}$	100	kPa

Testing laboratory	ISFH CalTeC	http://www.isfh.de	
Test report(s)	006-20/K1	**Dated**	21.06.2021
	007-20/KT1		21.06.2021
	008-20/KT1		21.06.2021
	035-20/KT1 (origin of given performance parameters)		21.06.2021

Comments of testing laboratory — Datasheet version: 6.1, 2019-07-11

The collector shows a thermal switching behaviour caused. It is offered with different switching temperatures,

[1)]the highest results in a standard stag. temperaure of 170 °C for temperatures above the switching temperature of 117 °C (at standard conditions) the following parameters apply: $\eta_{0,hem}$* = 0.830, a_1*= 6.64 W/m²K (Report 007-20/KT1),

[2)]the lowest results in a standard stag. temperature of 130 °C and for temperatures above the switching temperature of 66 °C (at standard conditions) the following parameters apply: $\eta_{0,hem}$* = 0.648, a_1*= 6.78 W/m²K (report 008-20/KT1)

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Supplementary Information	Issued	2021-06-24

Annual collector output in kWh/collector at mean fluid temperature ϑ_m [3)]

[3)] the calculation tool does not consider the switching behaviour of collectors, what might lead to minor annual annual collector output at high mean fluid temperatures for the collector with the lower switching temperature.

Standard Locations	Athens			Davos			Stockholm			Würzburg		
Collector name / ϑ_m	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C
Weiser Protect 800	1 162	929	710	940	736	552	683	514	372	736	553	395
Weiser Protect 1600	2 332	1 864	1 425	1 886	1 477	1 107	1 371	1 031	747	1 477	1 109	793
Weiser Protect 2400	3 502	2 800	2 141	2 833	2 218	1 663	2 059	1 548	1 122	2 218	1 666	1 190
Annual output per m² gross area	722	578	442	584	458	343	425	319	231	458	344	246
Annual efficiency, η_a	41%	33%	25%	36%	28%	21%	36%	27%	20%	37%	28%	20%
Fixed or tracking collector	Fixed (slope = latitude - 15°; rounded to nearest 5°)											
Annual irradiation on collector plane	1765 kWh/m²			1630 kWh/m²			1166 kWh/m²			1244 kWh/m²		
Mean annual ambient air temperature	18.5°C			3.2°C			7.5°C			9.0°C		
Collector orientation or tracking mode	South, 25°			South, 30°			South, 45°			South, 35°		

The collector is operated at constant temperature ϑm (mean of in- and outlet temperatures). The calculation of the annual collector performance is performed with the official Solar Keymark spreadsheet tool Scenocalc Ver. 6.1 (July 2019). A detailed description of the calculations is available at http://www.estif.org/solarkeymarknew/

Additional Information

Collector heat transfer medium				Water-Glycole	
The collector is deemed to be suitable for roof integration				No	
The collector was tested successfully under the following conditions:					
Climate class (A+, A, B or C)				A	--
G (W/m²) >	1000	ϑ_a (°C) >	20	H_x (MJ/m²) >	600
Maximum tested positive load				4500	Pa
Maximum tested negative load				3250	Pa
Hail resistance using steel ball (maximum drop height)				2	m

Additional collector attribute(s)

- ☐ Using external power source(s) for normal operation
- ☐ Active or passive measure(s) for self-protection
- ☐ Co-generating thermal and electrical power
- ☐ Façade collector(s)

Energy Labelling Information		Additional Informative Technical Data	
	Reference Area, A_{sol} (m²)	Hydraulic Designation Code	Aperature Area, A_a (m²)
Weiser Protect 800	1.61	1-H-12S-C:33,745-D	1.01
Weiser Protect 1600	3.23	1-H-12S-C:33,1495-D	2.03
Weiser Protect 2400	4.85	1-H-12S-C:33,2245-D	3.04

Data required for CDR (EU) No 811/2013 - Reference Area	
Collector efficiency (η_{col})	37%

Remark: Collector efficiency (ηcol) is defined in CDR (EU) No 811/2013 as collector efficiency of the solar collector at a temperature difference between the solar collector and the surrounding air of 40 K and a global solar irradiance of 1000 W/m², expressed in % and rounded to the nearest integer. Deviating from the regulation ηcol is based on reference area (Asol) which is aperture area for values according to EN 12975-2 or gross area for ISO 9806:2017.

Data required for CDR (EU) No 812/2013 - Reference Area A_{sol}		
Zero-loss efficiency (η_0)	0.44	--
First-order coefficient (a_1)	1.40	W/(m²K)
Second-order coefficient (a_2)	0.005	W/(m²K²)
Incidence angle modifier IAM (50°)	0.98	--

Remark: The data given in this section are related to collector reference area (A_{sol}) which is aperture area for values according to EN 12975-2 <u>or</u> gross area for ISO 9806. Consistent data sets for either aperture or gross area can be used in calculations like in the regulation 811 and 812 and simulation programs.

Explanation of the Solar Keymark certificate

For a quick and easy assessment of a collector's performance, you should take a look at the second or fourth page of the Keymark certificate. Here, the expected annual yields are given for the respective collectors, depending on the location and the temperature difference between the collector and the outside temperature.
These values are determined by a simulation taking into account the location, position of the sun and weather influences. The collectors are optimally aligned in this simulation. The difference in yield between collectors with power and standard tubes is clearly visible here, for example.

HP-collector with reflector

Annual collector output in kWh/collector at mean fluid temperature ϑ_m [3)]

[3)] the calculation tool does not consider the switching behaviour of collectors, what might lead to minor annual annual collector output at high mean fluid temperatures for the collector with the lower switching temperature.

Standard Locations		Athens			Davos			Stockholm			Würzburg		
Collector name	ϑ_m	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C
Weiser Protect 1000		1 378	1 141	917	1 140	929	739	820	644	496	883	693	528
Weiser Protect 2000		2 765	2 289	1 841	2 288	1 865	1 483	1 646	1 293	995	1 773	1 391	1 060
Weiser Protect 3000		4 152	3 437	2 764	3 436	2 801	2 227	2 472	1 941	1 494	2 662	2 089	1 591

HP-collector without reflector

Annual collector output in kWh/collector at mean fluid temperature ϑ_m [3)]

[3)] the calculation tool does not consider the switching behaviour of collectors, what might lead to minor annual annual collector output at high mean fluid temperatures for the collector with the lower switching temperature.

Standard Locations		Athens			Davos			Stockholm			Würzburg		
Collector name	ϑ_m	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C
Weiser Protect 800		1 162	929	710	940	736	552	683	514	372	736	553	395
Weiser Protect 1600		2 332	1 864	1 425	1 886	1 477	1 107	1 371	1 031	747	1 477	1 109	793
Weiser Protect 2400		3 502	2 800	2 141	2 833	2 218	1 663	2 059	1 548	1 122	2 218	1 666	1 190

Figure1: Comparison of yields per collector in Würzburg at Tm = 50°C

For a comparison with other collectors, the yields must be divided by the gross area of the respective collector. The yield per square meter of collector area is then obtained.

Difference in efficiency between power and standard collectors

The certificate shows that the efficiency of our collectors with power tubes is lower than that of our collectors with standard tubes.

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HP- collector without reflector (page 1)

η0, b	a1	a2
-	W/(m²K)	W/(m²K²)
0.444	1.40	0.005

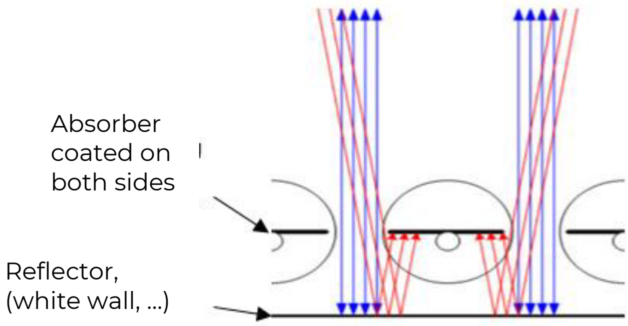
ca. +15 %

HP- collector with reflector (page 1)

η0, b	a1	a2
-	W/(m²K)	W/(m²K²)
0.511	1.43	0.004

Fig. 2: Difference in efficiency between df standard and power tube collectors with vertical irradiation

The reason for this is that the efficiency calculations are based on the aperture area1 at vertical irradiation. This is larger for collectors with power tubes than for those with standard tubes. Due to the design, only very little light hits the additional rear absorber surface of the power tubes at exactly vertical irradiation.



Most of the light is reflected directly in the case of vertical irradiation; no light falls on the lower absorber surfaces.
Frequency: briefly, when the sun is exactly vertical above the collector.

With oblique irradiation, the light is reflected by the reflector onto the lower absorber surfaces.
Frequency: at all other positions of the sun during the day.

Figure3: Radiation pattern with power tubes and different positions of the sun

This is why collectors with power tubes have almost the same peak output as standard collectors. If the almost identical peak output is now related to the larger aperture area of the power collector, this results in a lower efficiency. As soon as the light falls on the power collector at an angle and the rear absorber surface is irradiated, the efficiency increases.

[1] The aperture area describes the area through which usable light enters the collector. With standard tubes, this is only the area where there are actually tubes. With power tubes, the light that passes between the tubes and is reflected by a surface behind them onto the backs of the tubes is also used. For this reason, the area between the tubes also counts towards the aperture area for power tubes with an absorber on the back. This is therefore larger than for a collector with standard tubes without rear absorbers.

A reflector is required so that the power collectors can achieve their full output. A white façade or a zinc sheet roof can serve as a reflector. Tiles can be provided with a special paint/coating.

Please note: The reflector is not part of the collectors and must be provided by the customer or can be ordered separately. Without a reflector, only the yields of a standard collector are achieved.

The measured angle influence factors are listed directly below the efficiency in the Keymark certificate.

Incidence angle modifier test method		Quasi dynamic - outdoor								
Incidence angle modifier	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
Transversal	$K_{\theta T,coll}$	1.04	1.06	1.08	1.07	1.07	1.03	0.69	0.34	0.00
Longitudinal	$K_{\theta L,coll}$	1.00	1.00	0.99	0.98	0.96	0.93	0.86	0.64	0.00

Figure4: Angle influence factors of the hp collector with power tubes (page 2)

They describe the increase in output with a change in the angle of irradiation. For example, the output is 1.04 times higher at an angle of irradiation of 10° than with vertical irradiation.