Summary of EN 12975 Test Results, annex to Solar KEYMARK Certificate	Licence Number	011-7S660 R
	Issued	2014-08-28

Company holding the	Ako Tec Produktionsgesellschaft mbH	Country	Germany
Brand (optional)	Ako Tec	Website	www.akotec.eu
Street, street number	Grundmühlenweg 3	E-mail	info@akotec.eu
Postal Code / City, province	16278 Angermünde	Tel/Fax	49 (0)3331 29 66 88/ (0)3212 12 76 490

Collector Type (flat plate glazed/un-glazed; evacuate tubular)	Evacuated tubular collector
Thermal / photo voltaic hybid collector? (PVT collector)	No
Integration in the roof possible ? (manufacturers declaration)	No

Collector name	Aperture area (Aa)	Gross length	Gross width	Gross height	Gross area (AG)	Power output per collector module G = 1000 W/m², Tm-Ta 0 K	10 K	30 K	50 K	70 K
	m²	mm	mm	mm	m²	W	W	W	W	W
OEM Vario 2400-30 hp	3.05	2 208	2 247	115	**4.96**	2 144	2 075	1 927	1 767	1 595
OEM Vario 1600-20 hp	2.03	2 208	1 495	115	**3.30**	1 427	1 381	1 283	1 176	1 061
OEM Vario 800-10 hp	1.02	2 208	745	115	**1.64**	717	694	644	591	533
OEM Vario 400-5 hp	0.51	2 208	373	115	**0.82**	359	347	322	295	267

Performance test method	Glazed liquid heating collector - steady state - outdoor			
Performance parameters related to aperture	η0	a1	a2	
Units	-	W/(m²K)	W/(m²K²)	
Test results - Flow rate and fluid see note 1	0.703	2.224	0.005	

Bi-directional incidence angle	Yes	*Kϑ values are obligatory for 50°.*									
Incidence angle modifiers Kθ(θT)	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
transversal direction	Kθ(θT)	1.02	1.02	1.02	1.05	1.05	1.00	0.73		0.00
Incidence angle modifiers Kθ(θL)	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
longitudinal direction	Kθ(θL)	1.00	1.00	0.99	0.98	0.97	0.94	0.88		0.00

Stagnation temperature - Weather conditions see note 2	Tstg		°C
Effective thermal capacity	ceff = C/Ag	4.14	kJ/(m²K)
Max. intende operation temperature - see note 3	Tmax,op	300	°C
Max. operation pressure - see note 3	pmax,op	1000	kPa

Pressure drop table - for a collector family, the values shall be for the module with highest ΔP per m² aperture area

Flow rate	kg/(s m²)	0.014	0.028	0.042	0.056	0.083	0.111	0.139	0.167		
Pressure drop, ΔP	Pa	133	420	846	1412	2962	5070	7736	10960		

Optional weather data	Location		Link	
Testing Laboratory	TÜV Rheinland Energie und Umwelt GmbH			
Website	www.tuv.com/st			
Test report id. number	21210919_800_10hp; 21210919_2400_30hp	Date of test report	all 2010-07-28	
During the test GDIF/GTOT was always between	0.08	and	0.85	

Comments of testing laboratory:

*The collector was tested with a black backside sheet to minimize backside reflectivity. The tested collector was build with the so called Narva power tube with backside coating. If the standard tube with only front side coating will be used, the output performance will be the same as for the OEM Vario 2400-30 hp type tested with a black backside sheet. An additional thermal performance test with the collector OEM Vario 3000-30 hp using a high efficiency backside reflector is given on page 3 and 4.

Note 1	Flow rate	0.033	kg/(s m²)	Fluid	Water
Note 2	Irradiance, G = 1000 W/m²; Ambient temperature , Ta=30 °C				
Note 3	Given by manufacturer				

TÜV Rheinland Energie und Umwelt GmbH
Am Grauen Stein
D - 51105 Köln
test lab

Datasheet version: 4.05, 2013-11-07

Annual collector output based on EN 12975 Test Results, annex to Solar KEYMARK Certificate	Licence Number	011-7S660 R
	Issued	28.08.2014

Annual collector output kWh/module

Collector name	Location and collector temperature (Tm)											
	Athens			Davos			Stockholm			Würzburg		
	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C
OEM Vario 2400-30 hp	3 621	2 937	2 313	2 951	2 357	1 832	2 134	1 636	1 228	2 309	1 770	1 313
OEM Vario 1600-20 hp	2 410	1 955	1 539	1 964	1 568	1 220	1 421	1 089	817	1 537	1 178	874
OEM Vario 800-10 hp	1 211	982	773	987	788	613	714	547	411	772	592	439
OEM Vario 400-5 hp	605	491	387	493	394	306	357	274	205	386	296	220

Collector mounting: Fixed or tracking	Fixed; slope = latitude - 15° (rounded to nearest 5°)

Overview of locations

Location	Latitude °	Gtot kWh/m²	Ta °C	Collector orientation or tracking mode
Athens	38	1 765	18.5	South, 25°
Davos	47	1 714	3.2	South, 30°
Stockholm	59	1 166	7.5	South, 45°
Würzburg	50	1 244	9.0	South, 35°

Gtot	Annual total irradiation on collector plane	kWh/m²
Ta	Mean annual ambient air temperature	°C
Tm	Constant collector operating temperature (mean of in- and outlet temperatures)	°C

The calculation of the annual collector performance is performed with the official Solar Keymark spreadsheet tool ScenoCalc. The collector output is calculated hour by hour according to the efficiency parameters from the Keymark test using constant collector operating temperature (Tm). A detailed description of the calculations is available at http://www.sp.se/en/index/services/solar/ScenoCalc/Sidor/default.aspx.

Summary of EN 12975 Test Results, annex to Solar KEYMARK Certificate	Licence Number	011-7S660 R
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Company holding the	Ako Tec Produktionsgesellschaft mbH	Country	Germany
Brand (optional)	Ako Tec	Website	www.akotec.eu
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Postal Code / City, province	16278 Angermünde	Tel/Fax	49 (0)3331 29 66 88/ (0)3212 12 76 490

Collector Type (flat plate glazed/un-glazed; evacuate tubular)	Evacuated tubular collector
Thermal / photo voltaic hybid collector? (PVT collector)	No
Integration in the roof possible ? (manufacturers declaration)	No

Collector name	Aperture area (Aa)	Gross length	Gross width	Gross height	Gross area (AG)	Power output per collector module Gb = 850 W/m²; Gd = 150 W/m² Tm-Ta 0 K	10 K	30 K	50 K	70 K
	m²	mm	mm	mm	**m²**	W	W	W	W	W
OEM Vario 3000-30 hp	4.46	2 170	2 253	115	**4.89**	2 376	2 310	2 177	2 044	1 911
OEM Vario 2000-20 hp	2.95	2 170	1 490	115	**3.23**	1 571	1 527	1 440	1 352	1 264
OEM Vario 1000-10 hp	1.47	2 170	740	115	**1.61**	780	759	715	671	628
OEM Vario 500-5 hp	0.73	2 208	370	115	**0.82**	390	379	357	336	314

Performance test method	Liquid heating collector - quasi-dynamic - outdoor								
Performance parameters related to aperture	η0b	c1	c2	c3	c4	c6	Kθd		
Units	-	W/(m²K)	W/(m²K²)	J/(m³K)	-	s/m	-		
Test results - Flow rate and fluid see note 1	0.514	1.489	0.000	0.000	0.000	0.000	1.242		

Bi-directional incidence angle	Yes	*Kϑ values are obligatory for 50°.*								
Incidence angle modifiers Kθ(θT)	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
transversal direction	Kθ(θT)	1.33	1.36	1.17	1.28	1.23	1.17	1.03		0.00
Incidence angle modifiers Kθ(θL)	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
longitudinal direction	Kθ(θL)	1.00	1.00	0.99	0.98	0.97	0.94	0.88		0.00

Stagnation temperature - Weather conditions see note 2	Tstg	158	°C
Effective thermal capacity	ceff = C/Ag	9.97	kJ/(m²K)
Max. intende operation temperature - see note 3	Tmax,op	160	°C
Max. operation pressure - see note 3	pmax,op	1000	kPa

Pressure drop table - for a collector family, the values shall be for the module with highest ΔP per m² aperture area										
Flow rate	kg/(s m²)									
Pressure drop, ΔP	Pa									

Optional weather data	Location		Link	
Testing Laboratory	TÜV Rheinland Energie und Umwelt GmbH			
Website	www.tuv.com/st			
Test report id. number	21210919_1000_10hp; 21210919a_3000_30hp	Date of test report	all 2010-07-28	

During the test GDIF/GTOT was always between	0.08	and	0.85

Comments of testing laboratory:

The collector OEM Vario 2400-30 hp was tested as OEM Vario 3000-30 hp with a high efficiency backside reflector.

Note 1	**Flow rate**	0.022	kg/(s m²)	**Fluid**	Water
Note 2	**Irradiance, G = 1000 W/m²; Ambient temperature , Ta=30 °C**				
Note 3	**Given by manufacturer**				

TÜV Rheinland Energie und Umwelt GmbH
Am Grauen Stein
D - 51105 Köln

Datasheet version: 4.05, 2013-11-07

Annual collector output based on EN 12975 Test Results, annex to Solar KEYMARK Certificate	Licence Number	011-7S660 R
	Issued	28.08.2014

Annual collector output kWh/module

Collector name	Location and collector temperature (Tm)											
	Athens			Davos			Stockholm			Würzburg		
	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C
OEM Vario 3000-30 hp	4 841	4 188	3 612	4 087	3 515	3 027	2 957	2 466	2 064	3 180	2 650	2 212
OEM Vario 2000-20 hp	3 201	2 770	2 389	2 703	2 325	2 002	1 955	1 630	1 365	2 103	1 752	1 463
OEM Vario 1000-10 hp	1 590	1 375	1 186	1 342	1 154	994	971	810	678	1 044	870	726
OEM Vario 500-5 hp	795	688	593	671	577	497	485	405	339	522	435	363

Collector mounting: Fixed or tracking	Fixed; slope = latitude - 15° (rounded to nearest 5°)

Overview of locations

Location	Latitude °	Gtot kWh/m²	Ta °C	Collector orientation or tracking mode
Athens	38	1 765	18.5	South, 25°
Davos	47	1 714	3.2	South, 30°
Stockholm	59	1 166	7.5	South, 45°
Würzburg	50	1 244	9.0	South, 35°

Gtot	Annual total irradiation on collector plane	kWh/m²
Ta	Mean annual ambient air temperature	°C
Tm	Constant collector operating temperature (mean of in- and outlet temperatures)	°C

The calculation of the annual collector performance is performed with the official Solar Keymark spreadsheet tool ScenoCalc. The collector output is calculated hour by hour according to the efficiency parameters from the Keymark test using constant collector operating temperature (Tm). A detailed description of the calculations is available at http://www.sp.se/en/index/services/solar/ScenoCalc/Sidor/default.aspx.

Explanation of Solar Keymark Certificate

For a quick and easy performance evaluation of a collector, you can read second or fourth page of the Solar Keymark Certificate. Here you can see expected annual collector yield depending on the location and the temperature difference between collector and ambient temperature. These values are determined by simulation considering standard location, position of the Sun and weather conditions. Orientation of the collectors is optimized in this simulation. The yield difference between collectors with power tube and standard tube is clearly visible here.

df collector with Standard tubes (page 2)

Annual collector output kWh/module												
	Location and collector temperature (Tm)											
	Athens			Davos			Stockholm			Würzburg		
Collector name	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C
OEM Vario 2400-30	4 124	3 491	2 865	3 424	2 836	2 289	2 484	1 995	1 558	2 688	2 162	1 685
OEM Vario 1600-20	2 744	2 323	1 907	2 278	1 887	1 523	1 653	1 328	1 037	1 788	1 439	1 121
OEM Vario 800-10	1 379	1 167	958	1 145	948	765	830	667	521	899	723	563
OEM Vario 400-5	689	584	479	572	474	383	415	334	260	449	361	282

df collector with Power tubes (page 4)

Annual collector output kWh/module												
	Location and collector temperature (Tm)											
	Athens			Davos			Stockholm			Würzburg		
Collector name	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C	25°C	50°C	75°C
OEM Vario 3000-30	5 231	4 559	3 926	4 426	3 809	3 250	3 192	2 667	2 215	3 458	2 893	2 399
OEM Vario 2000-20	3 491	3 043	2 620	2 954	2 543	2 169	2 131	1 780	1 478	2 308	1 931	1 601
OEM Vario 1000-10	1 740	1 516	1 306	1 472	1 267	1 081	1 062	887	737	1 150	962	798
OEM Vario 500-5	870	758	653	736	633	541	531	444	368	575	481	399

Figure 1: Comparison of yield per collector in Würzburg at T_m= 50ºC

For the comparison between yield of different collectors, the gross area of the collector must be considered. Then we get the yield of collector per m^2 area of the collector.

Difference between efficiency of Power and standard collectors

In certificate, it can be seen that the efficiency of our collectors with power tubes is lower than that of our collectors with standard tubes.

df Kollektor mit Standardröhren (Seite 1)

η0b	c1	c2
-	W/(m²K)	W/(m²K²)
0.774	1.936	0.006

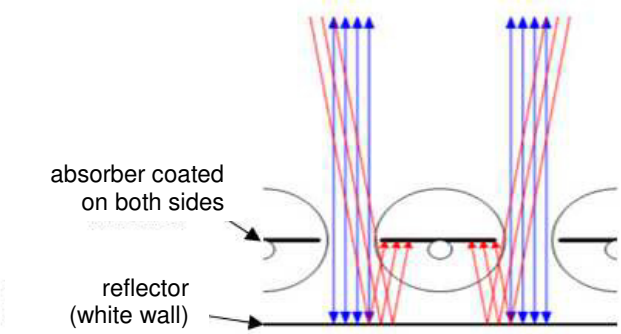
ca. - 20%

df Kollektor mit Powerröhren (Seite 3)

η0b	c1	c2
-	W/(m²K)	W/(m²K²)
0.559	1.485	0.002

Figure 2: Difference between efficiency of Power and Standard tube collectors at normal irradiation

The reason for this is, efficiency calculations are based on the aperture area at the normal irradiation. Aperture area for power tubes collector is greater than that of standard tubes collector. Very less light incidents on to the rear side of the extra absorber area because of normal irradiation and construction of collectors.



At the normal irradiation, most of the light is directly reflected from the reflector and light does not reach the lower absorber surface area.
Frequency: Short time, when Sun is exactly perpendicular to the surface of collector.
At the inclined irradiation, the light is reflected from reflector on to the lower absorber surface area.
Frequency: At all other positions of the Sun for the day.

Figure 3: Path of irradiation on power tube collector and different sun positions

Therefore, the collectors with power tubes have almost same peak power as standard tube collectors. Now the power tube collector with larger aperture area has almost the same peak power but with relatively low efficiency. When light incidents inclined to the surface of power tube collector, light is reflected on to the rear side of absorber surface area and thus the efficiency increases.
A reflector is required for power tube collector to achieve full power. A white façade or zinc coated sheet can be used as reflector. Brick can be used with special colour or coatings.

Attention: The reflector is not a part of the collector and is to be provided on the site. Yield of the collector can be achieved up to yield of standard tubes collector if reflector is not used.

You can see Influence of angle listed directly below efficiency in Keymark certificate.

Bi-directional incidence angle	Yes	*Kϑ values are obligatory for 50°.*								
Incidence angle modifiers Kθ(θT)	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
transversal direction	Kθ(θT)	1.35	1.17	1.25	1.20	1.22	1.15	0.83		0.00

Figure 4: Influence of angles on the df collector with power tubes

It describes the performance improvement with the change in irradiation angle. For example, power at 10 º is 1.35 times higher than the normal irradiation.

[1] Aperture area describes the area of collector on which useful light incidents. For standard tubes it is only the area covered by the tubes. In case of power tubes, light also passes through area between two tubes and then it is reflected on to the rear side of the absorber surface area which can be used. Therefore, area between two tubes and the area on rear side of the absorber surface also constitutes aperture area. Therefore, it is greater than aperture area of standard tube collector without rear side absorber surface.