



**TECHNICAL MANUAL**

**VACUUM TUBE SOLAR COLLECTORS**

**VTS**



Solar Keymark  
OFFICIAL QUALITY MARK OF THE EUROPEAN UNION



## DESCRIPTION

Calpak VTS is a vacuum tube solar collector, consisting of twin wall glass tubes and an air vacuum between their walls of  $5 \cdot 10^{-3}$  Pa.

These tubes are manufactured from borosilicate glass. The outer tube has a diameter  $d=47\text{mm}$  and is 1.8mm thick. Respectively, the inner tube has a diameter  $d=33\text{mm}$  and is 1.5mm thick. The inner tube surface towards the vacuum is specially treated to allow selective behavior.

Each of these tubes contains a U-shaped copper tube with  $\Phi 3/8''$  diameter. This is fitted with copper fins to improve heat transmission properties. Each tube is connected to a heat conductive fluid input header,  $\Phi 18$  size, and a similar output header, also  $\Phi 18$ . This fluid is circulating through the copper tubes.

These glass tubes containing the U shaped copper tubes are laid vertically while headers are horizontal. The entire assembly is mounted on a frame whose back is made from highly reflective aluminum. Its surface is parabolic shaped so that the radiation incident on the reflector, is routed to the vacuum tubes. The headers are insulated by glass wool and expanded polyurethane. They are protected by an electrostatically black painted aluminum cover.

The solar radiation incident on the outer glass tube - either directly or reflected - penetrates the interior through the vacuum. There, the selective surface absorbs heat and thus, the inner space of the tube is heated. The U shaped copper tube with the copper fins will then absorb heat and ultimately heat the conductive fluid circulating in the tube.

Although these vacuum tubes can withstand hail with hailstone size up to 2.5cm, in the unlikely event that they break, no safety issues will occur since the quantity of glass is minimal, and the tubes can be easily replaced without intervening to the conductive fluid closed circuit.

The operating pressure of the closed circuit of the VTS collectors can be 6 or 10 bar, depending on the installation design, considering that these collectors can withstand even higher pressures.

Furthermore, the cold water intake is by design located to the right when viewing the frontal surface of the collector, while the outlet is to the left. Both are located on a straight line to allow easy series connection. However, such a layout is not recommended for the Mediterranean climate, as there is increased risk of overheating.

The left outlet has a socket for mounting a temperature sensor.

## ANTIFREEZE PROTECTION OF COLLECTORS

In order to ensure the anti-freeze and anti-corrosion protection of the collector, we offer the Calpak thermal fluid, which is a propylene glycol based product (provided as an accessory).

This thermal fluid is mixed with water, at a minimum volume ratio of 20%.

In areas with low winter temperatures, this ratio changes, as shown in the table below:

Ambient Temperature °C	min.	-10 °C	-15 °C	-20 °C	-25 °C	-30 °C	-35 °C
Ratio of Calpak fluid – water by volume %	20	23	31	37	43	48	53

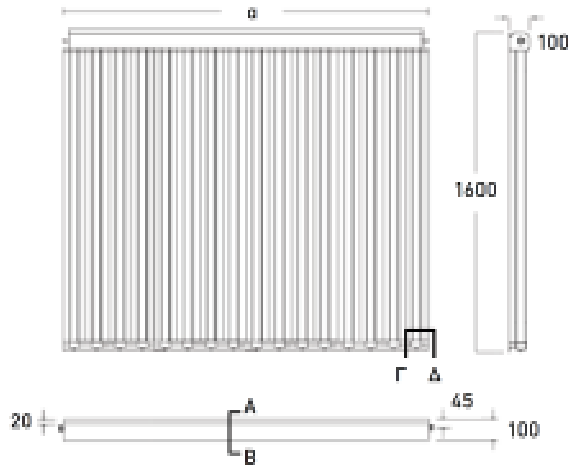
Thanks to the excellent heat insulation provided by the vacuum and their selective surface, Calpak VTS collectors are highly efficient in cold winter climates, where temperatures drop below zero centigrade. They are also very efficient in solar systems demanding the production of very hot water (e.g. food processing, finishing plants, etc.)

The Vacuum VTS collectors are designed for installation on flat roofs and inclined tiled roofs, by using the corresponding supports that are available as accessories. The Vacuum VTS collectors are available with 10-12-14 and 16 tubes. Upon request, they can be delivered with other sizes, between 6-16 tubes.

The Vacuum Calpak VTS collectors are certified with the SOLAR KEY MARK reliability and performance mark awarded by the EU (CEN). The mark is awarded after the performance of thorough tests by accredited government testing labs (e.g. NCSR-Dimokritos) or foreign laboratories (e.g. Stuttgart University, etc), performed according to the European Standards EN 12 975-1-2 and also provided that they are produced under the conditions stipulated in the ISO 9001:2000 standards.

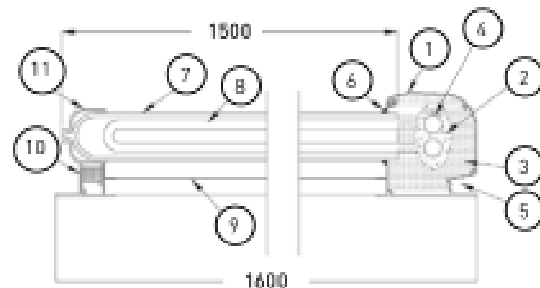
## Drawing of the Calpak VTS Collector

### FRONT & SIDE VIEW



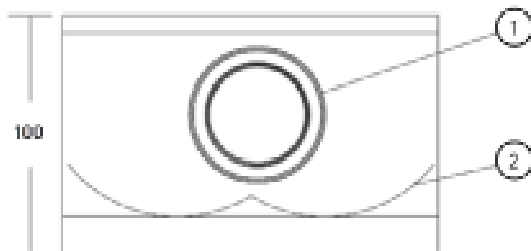
1. Header aluminum cover
2. Glass wool thermal Insulation
3. Expanded polyurethane thermal insulation
4. Header copper tubes,  $\Phi 18$  ( $\Phi 22$ )
5. Recess securing the collector
6. O-rings made from EPDM or equivalent
7. Glass vacuum tubes

### COLLECTOR SECTIONAL VIEW, AB



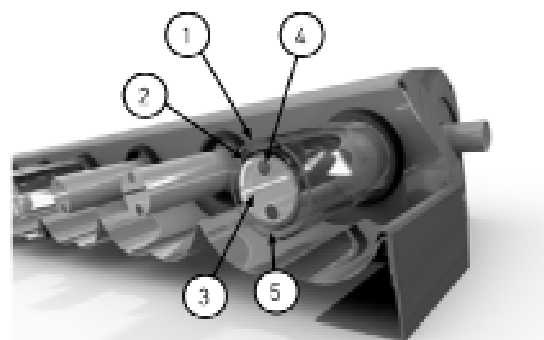
8. U shaped copper tube
9. Aluminum reflector
10. Aluminum base with mounting recess
11. Plastic caps with UV protection supporting the vacuum tubes

### SECTIONAL VIEW CD, DETAIL



1. Vacuum tube
2. Parabolic Aluminum Reflector

### SECTIONAL VIEW OF TUBE



1. Outer Glass Tube
2. Inner glass tube with selective surface
3. Copper fins (with ultrasonic welded assembly)
4. U shaped copper tube
5. Air vacuum

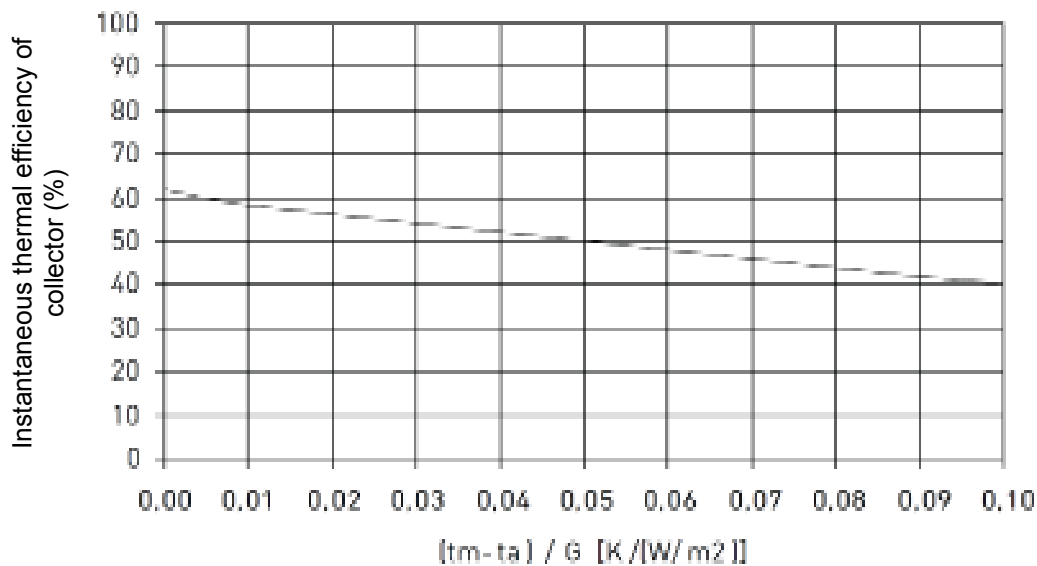
## TECHNICAL CHARACTERISTICS

Model		10 VTS	12 VTS	14 VTS	16 VTS
Number of tubes		10	12	14	16
Total surface area	m <sup>2</sup>	1.79	2.13	2.48	2.86
Window surface	m <sup>2</sup>	1.62	1.96	2.26	2.55
Absorber surface	m <sup>2</sup>	1.64	1.99	2.30	2.60
Dimension: width (a)	mm	1193	1420	1653	1887
Dimension: height (b)	mm	1600	1600	1600	1600
Dimension: thickness (c)	mm	110	110	110	110
Active heat capacity	KJ/k	63	76	89	102
Weight	kg	29.5	35	41	47
Content of thermal fluid	kg	2.1	2.5	2.9	3.3
Standby temperature	°C	278	278	278	278
Hydraulic connections		Φ18 (Φ22)*	Φ18 (Φ22)*	Φ18 (Φ22)*	Φ18 (Φ22)*
Max. operating pressure	bar	10	10	10	10
Time constant	sec	228	228	228	228
Coefficient of angle of incidence at 50°		96%	96%	96%	96%

**\* Only on special order and in significant quantities**

## Instantaneous Performance Curve of Vacuum Calpak VTS solar collector

based on the absorber surface



$$n_A = Q / A_A G$$

$$n_A = n_{0A} - U_A \frac{t_m - t_A}{G}$$

Type	VTS
$n_o$	0.62
U	2.11

- Q = Effective output power of the collector (w)  
 G = Total solar radiation intensity (w/m<sup>2</sup>)  
 A = Collector absorber area (m<sup>2</sup>)  
 n = Collector thermal output (%)  
 U = Total coefficient of collector losses (w/m<sup>2</sup>k)

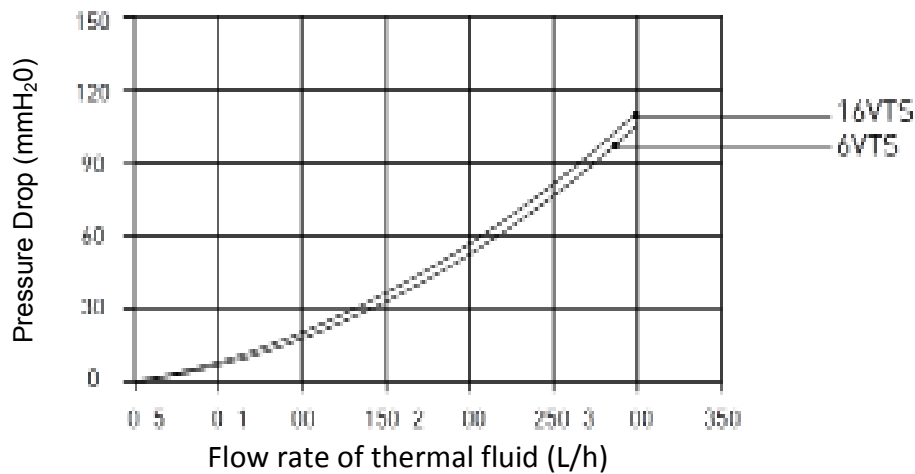
## Secondary Equation of Instantaneous Performance of Solar collectors Vacuum Calpak VTS

based on the window surface (Solar KeyMark)

$$n = n_o - a_1 \frac{t_m - t_A}{G} - a_2 G \frac{(t_m - t_A)^2}{G}$$

Type	VTS	
$n_o$	0.51	
$a_1$	0.84	W/m <sup>2</sup> k
$a_2$	0.004	W/m <sup>2</sup> k <sup>2</sup>

## Thermal Fluid Pressure Drop Curve



*Note: The pressure drop curves of intermediate models are between the two extreme curves and can be determined proportionally.*

Recommended flow of thermal fluid  $\sim 40 \text{ l/m}^2, \text{ h}$

Recommended inclination of the collector towards the exit of the warm fluid 1-2%.

## Efficiency drop due to deviation

The performance curve of p. 6 refers to collectors oriented to the South, at a slope of 45° with respect to the horizontal plane. Regarding other positions, performance is slightly reduced for slope angles to 15°, while for higher angles it may reach up to 30%.

The following table provides the approximate anticipated performance reductions on an annual basis (percentage, %).

The table is only exemplary and should be verified for large installations.

Inclined to the horizontal	SOUTH	SE	SW	EAST	WEST
15°	-9%	-12%	-12%	-20 %	-19%
25°	-9%	-9%	-9%	21%	20%
35°	-1%	-8%	7%	23%	21%
45°	0%	-8%	7%	26%	24%
55°	-1%	-10%	8%	30%	27%

## Accessories

The following accessories are provided, to facilitate installation:

- Supports for flat roofs
- Supports for inclined tiled roofs
- $\Phi 18$  connection fitting ( $\Phi 22$  upon special order)
- Special covers for increased collector protection in the summer
- Calpak thermal fluid based on non-toxic pharmaceutical propylene glycol, packaged in 1-, 2-, 5- and 10-liter canisters.
- Automatic ventilators
- Tee fittings, protection sockets and sensors
- Full range of solar stations for controlling the operation of central solar systems, with or without circulation pump.

**Note:** The company reserves the right to alter specifications without prior notice.

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