Qualification Test of Solar Absorber Coating Durability

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Part 2

The test procedure applied is basing on the service life assessment methodology developed by the IEA-SHCP under consideration of the latest further developments of the procedure [1].The full test consists of 3 parts:

Part 1: Stability with regards to high temperature

Part 2: Stability with regards to high humidity and condensation

Part 3: Stability with regards to atmospheric corrosion (SO_2)

The test allows the qualification of solar absorber coatings to be used in ventilated flat plate collectors with a maximum loss in system performance of 5 % during 25 years of operation. The loss in performance was evaluated according the performance criterion function:

$PC = -\Delta\alpha_S + 0.5\Delta\varepsilon_{100}$.

Test material

Commissioner:	ALMECO GmbH Claude Breda Straße 3 D-06406 Bernburg, Germany
Trade name:	TiNOX energy Cu
Description:	Protection and antireflection layer on the basis of an Oxide – CERMET absorber multilayer – adhesion layer – Copper substrate
Date of delivery:	August 2013
Expiration date:	September 2016 (The test result is no longer valid after substantial changes of the coating or substrate)

Test results

The test material has passed part 2 of the test, i.e. with regards to the stability against high humidity and the occurrence of condensed water the absorber is qualified to be used in single glazed flat plate collectors.

Measuring of optical properties

Solar absorptance, α_S

Solar absorptance, α_S, was measured with a BRUKER IFS 66 UV-VIS-MIR Fourier-transform spectrophotometer equipped with an integrating sphere. 'Spectralon' diffuse reflectance standard was used as a reflectance reference. α_S was calculated for airmass (AM) 1.5 using hemispherical solar spectral irradiance data as described in ISO 9845-1.

Thermal emittance, ε_{100}

The thermal emittance, ε_{100}, was measured using the same instrument as for solar absorptance measurements. However, an 'Infragold' reflectance standard was used as a reference. The black body radiation spectrum for a temperature of 100°C (373 K) was used for the calculation of ε_{100}. It was generated according to Planck's law of black body radiation.

Testing chambers

A Horstmann humidity cabinet, type HS 220 K 45 (volume $0.22m^3$) was used for the condensation tests.
The samples were mounted on a water cooled metal sample holder, which was tilted 45°.
The temperature of the samples was measured with a calibrated (± 1°C) Pt-100 sensor. The temperature of the cabinet was 5°C higher than the sample temperature. The humidity inside the cabinet was 95% RH. The samples were electrically insulated from the sample holder by Teflon films.

Evaluation of test results

The degradation of the absorber surfaces was evaluated according to a performance criteria function which is defined as

$$PC = -\Delta\alpha_S + 0.5\Delta\varepsilon_{100}$$

where $\Delta\alpha_S$ and $\Delta\varepsilon_{100}$ are the changes in α_S and ε_{100} respectively.

1. Optical properties of unaged absorber surface

The mean values of solar absorptance, α_s and thermal emittance, ε_{100}, for unaged absorbers are given in Table 1 below.

Table 1 Optical properties of unaged absorber samples. The values given are the mean values of 21 samples.

Values	Optical properties of unaged absorber coatings	
	Solar Absorptance, α_s	Emittance, ε_{100}
Mean value	0.949	0.041
Standard deviation	0.001	0.001
Minimum value	0.947	0.038
Maximum value	0.951	0.043

The test specimens are qualified for testing, since the standard deviation for solar absorptance α_s and thermal emittance ε_{100} are less than 0.01 and 0.04, respectively.

2. Test conditions

To assure permanent condensation of water on the absorber surface, the ambient temperature was kept 5°C above the sample temperature at a humidity level of 95%. Figure 1 shows the testing times which are equivalent to the load caused by humidity and wetness in a standard flat plate collector during 25 years of operation.

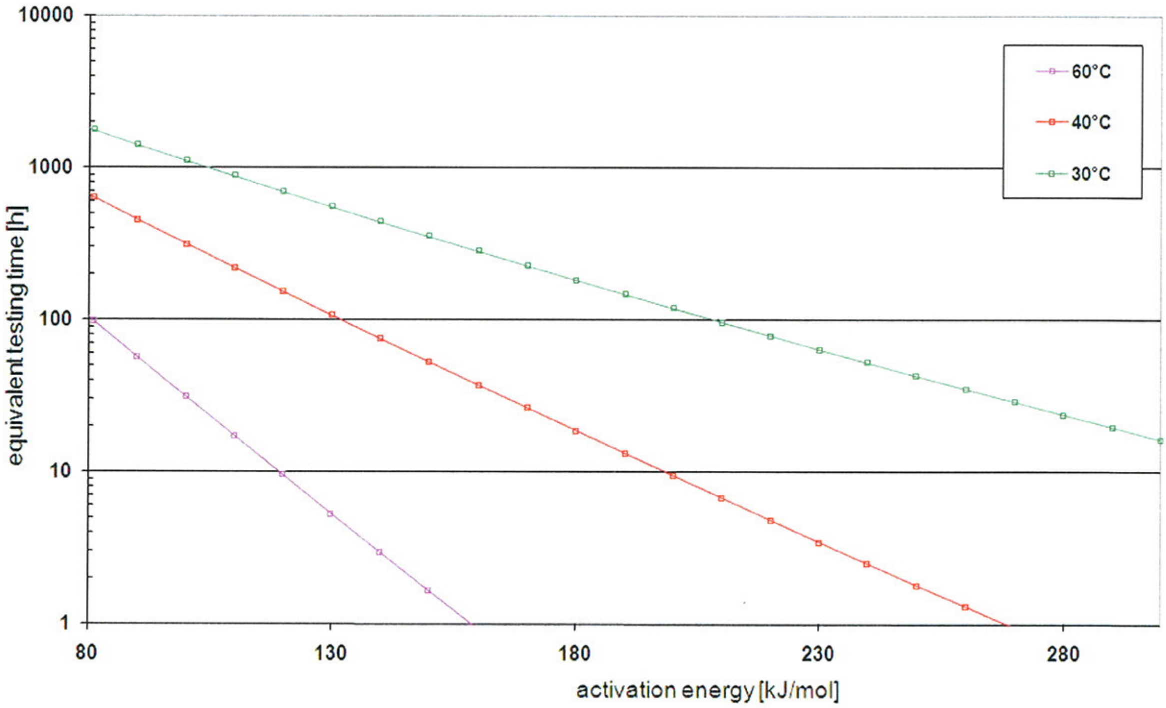

Figure 1 Equivalent testing times for the absorber tested for different testing temperatures.

3. Test Results

The extent of degradation (PC-function) for the absorber coating after exposure at 40°C under continuous condensation is given in Table 2&3 below.

Table 2 The extent of degradation at the 40°C condensation test.

sample	Changes in optical properties at 40°C sample temperature					
	80h			150h		
	$-\Delta\alpha_s$	$\Delta\varepsilon_{100}$	PC	$-\Delta\alpha_s$	$\Delta\varepsilon_{100}$	PC
1	-0.001	0.000	-0.001	0.001	0.003	0.003
2	0.000	0.005	0.003	-0.001	0.002	0.000
3	-0.001	0.006	0.002	-0.001	0.006	0.002
mean			**0.001**			**0.002**

Table 3 The extent of degradation at the 40°C condensation test.

sample	Changes in optical properties at 40°C sample temperature					
	300h			**600h**		
	-$\Delta\alpha_s$	**$\Delta\varepsilon_{100}$**	**PC**	**-$\Delta\alpha_s$**	**$\Delta\varepsilon_{100}$**	**PC**
1	-0.003	0.005	-0.001	-0.005	0.005	-0.003
2	-0.002	0.004	0.000	-0.007	0.005	-0.005
3	0.002	0.006	0.005	-0.004	0.006	-0.001
mean			**0.002**			**-0.003**

As can be seen in Table 2&3 the mean value of the PC-function for the three test specimens does not exceed 0.015 after the maximum testing time of 600h. For this reason no secondary condensation test was needed for qualification.
The cross cut test (ISO 2409 for soft samples) had the result: GT 0 (i.e. no adhesion problem). Thus, the absorber coating has qualified with regards to its stability against high humidity and condensation and is supposed to withstand the load resulting from 25 years of operation in a ventilated flat plate collector.

4. References

[1] prEN 12975-3-1:2011; Solar Energy - Collector components and materials-Part 3: Absorber surface durability.

SPF-Solartechnik

Lukas Omlin
SPF Forschung / Projektmitarbeiter

Florian Ruesch
SPF Forschung / Projektmitarbeiter

Stefan Brunold
SPF Forschung / Institutsleiter Stv.