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Test Report

ISO/EN 22975-3 Part 3: *Absorber Surface Durability*

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Part A

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 coating was tested according to ISO/EN 22975-3 Part 3 with regards to:

Part A: Stability with regards to high temperature

Test material	
Commissioner:	ALMECO GmbH Claude Breda Strasse 3 D-06406 Bernburg, Germany
Trade name:	TiNOX energy Al
Description:	Selective solar absorber: PVD coating with protection and antireflection layer based on silica glass / cermet absorber multilayer / adhesion layer / aluminium substrate
Start of test:	October 2022
Completion of test:	February 2023
Expiration date:	February 2028 (The test result is no longer valid after substantial changes of the coating or substrate)

Test results

The test material has passed **part A (stability with regards to high temperature)** of the test according to ISO/EN 22975-3 and it is qualified to be used in single glazed flat plate collectors with double-side AR coated glass.

Preliminary testing

Sample conditioning

According to clause 5.2 of the ISO 22975-3 standard, the optical properties of three samples as-received were measured in order to determine the temperature for pre-conditioning using the Table B.1 from the standard. The results are presented in Table 1.

Table 1: Optical properties of three as-received samples and pre-conditioning temperature

	Sample V1	Sample V2	Sample V3	Mean value
Solar absorptance, α_s	0.957	0.956	0.958	**0.957**
Thermal emittance, ε_{100}	0.041	0.056	0.047	**0.048**
Temperature to be applied for pre-conditioning of the samples				**213°C**

Qualification for testing

In total, 18 samples have been pre-conditioned by tempering for 5 hours at the temperature given in Table 1. After pre-conditioning, an adhesion test according to clause 5.5 of the ISO 22975-3 standard was performed for three of the samples. The results are presented in Table 2. As the adhesion grade is ≤ 1, according to clause 4.3 of the ISO 22975-3, the three samples have passed the adhesion test.

Table 2: Result of the adhesion test performed on three samples after pre-conditioning

	Sample 1	Sample 2	Sample 3
Adhesion test result grade	0	0	0

The optical properties of the remaining 15 samples were measured. The value of the solar absorptance and thermal emittance was determined as specified in clause 5.3 and 5.4 from ISO/EN 22975-3. The results are presented in Table 3.

Table 3: Mean values of the optical properties of 15 samples after pre-conditioning

	Solar absorptance, α_s	Thermal emittance, ε_{100}
Mean value	0.958	0.048
Standard deviation	0.001	0.004
Minimum value	0.957	0.040
Maximum value	0.959	0.053

The standard deviation for solar absorptance and thermal emittance is less than 0.01 and 0.04, respectively (Table 3). Thus, according to clause 4.2 and 4.3 of the ISO 22975-3 standard, the test specimens are qualified for testing.

From the mean values of the optical properties from Table 3 and using the Table B.1 from ISO/EN 22975-3, the expected maximum absorber surface temperature (T_{max}) was determined (Table 4). This is needed to evaluate the testing temperature levels for qualification according to Table B.2 from ISO/EN 22975-3.

Table 4: Expected maximum absorber surface temperature (T_{max}) and testing temperature levels to be used for qualification

	Temperature [°C]
maximum absorber surface temperature T_{max}	213
first testing temperature T_1	291

Tests for assessing the thermal stability of absorber surfaces

According to clause 6.4.3 of the ISO/EN 22975-3 standard, three samples were exposed to the first testing temperature level T_1 for a testing time up to 600 h or until PC ≥ 0.05. The mean values of the Performance criterion (PC) determined for the three samples for different testing times (18, 36, 75, 150, 300 and 600 h) are shown in Table 5.

Table 5: PC mean value of three samples after testing at T_1

Time of exposure	18 h	36 h	75 h	150 h	300 h	600 h
PC	0.000	-0.001	-0.001	-0.001	0.000	-0.007

According to clause 7.4.2 of the ISO/EN 22975-3:2014, the absorber coating is qualified with regards to its thermal stability if after testing at the temperature level T_1 for a testing time t_1 of 600h, the $PC(t_1) \leq 0.015$ and the adhesion test of the three samples leads to a result grade ≤ 1.

Table 6: Results of the adhesion tests performed on three samples after 600 h of testing at temperature T_1.

	Sample 1	Sample 2	Sample 3
Adhesion test result grade	0	0	0

As the absorber coating meets the above required conditions, the test material has passed part A (stability with regards to high temperature) and it is qualified to be used in single glazed flat plate collectors.

SPF Institute for Solar Technology
Rapperswil, February 2023

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Annex

Deviations from the testing method

None.

Solar absorptance (α_s)

Hemispherical reflectance was measured with a BRUKER VERTEX 80 UV-VIS-MIR Fourier-transform spectrophotometer equipped with a 150 mm integrating sphere. 'Spectralon' diffuse reflectance standard was used as reflectance reference. The solar absorptance was calculated for airmass 1.5 using the hemispherical solar spectral irradiance data as described in ISO 9050:2003.

Thermal emittance (ε_{100})

For thermal emittance evaluation, the same instrument was used to measure the hemispherical reflectance, but with an 'Infragold' reflectance standard as a reference. The black body radiation spectrum for a temperature of 100°C (373 K) was used for thermal emittance calculation. It was generated according to Planck's law of black body radiation.

Performance criterion, PC

The performance criterion, which shows the changes in performance of an absorber surface in terms of solar absorptance and thermal emittance, was calculated using Eq. 1. For classification of the durability of the absorber coating surface according to the ISO/EN 22975-3:2014 standard, the following performance requirement is applied.

$$PC = -\Delta\alpha_s + 0.50\,\Delta\varepsilon \leq 0.05 \qquad \text{Eq. 1}$$

where: $\Delta\alpha_s$ is the change in the solar absorptance defined as:

$\Delta\alpha_s = \alpha_{s,t} - \alpha_{s,i}$, with $\alpha_{s,t}$ equal to the value of the solar absorptance at the actual time of the test, and with $\alpha_{s,i}$ equal to the initial value of solar absorptance.

and $\Delta\varepsilon$ is the change in the thermal emittance:

$\Delta\varepsilon = \varepsilon_t - \varepsilon_i$ with ε_t equal to the value of the thermal emittance at the actual time of the test and with ε_i equal to the initial value of thermal emittance.

Testing chamber

A Snijstaal circulating air oven (type P2000) was used for conditioning the samples and for the high temperature exposure. The temperature values were measured with a calibrated (±1 K) Pt-100 sensor.

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Detailed results

Nr.	Sample code	Reference		5h @ 213°C		18h		36h		75h		150h		300h		600h	
		α_s	ε_{100}	α_s	ε_{100}	α_s	ε_{100}	α_s	ε_{100}	α_s	ε_{100}	α_s	ε_{100}	α_s	ε_{100}	α_s	ε_{100}
1.	ALMC220900xZ	0.957	0.041	0.958	0.043												
2.	ALMC220901xZ	0.956	0.056	0.957	0.044												
3.	ALMC220902xZ	0.958	0.047	0.959	0.040												
4.	ALMC220903xZ			0.957	0.048												
5.	ALMC220904xZ																
6.	ALMC220905xZ																
7.	ALMC220906xZ			0.958	0.049												
8.	ALMC220907xZ			0.959	0.049												
9.	ALMC220908xZ			0.958	0.050	0.959	0.052	0.959	0.052	0.960	0.053	0.960	0.053	0.960	0.055	0.961	0.043
10.	ALMC220909xZ			0.958	0.051												
11.	ALMC220910xZ			0.959	0.042												
12.	ALMC220911xZ			0.959	0.044												
13.	ALMC220912xZ			0.958	0.045												
14.	ALMC220913xZ			0.959	0.048												
15.	ALMC220914xZ			0.958	0.051	0.959	0.054	0.959	0.050	0.960	0.052	0.960	0.053	0.960	0.055	0.961	0.044
16.	ALMC220915xZ			0.958	0.053												
17.	ALMC220916xZ			0.958	0.053	0.959	0.052	0.959	0.054	0.960	0.053	0.960	0.054	0.960	0.055	0.961	0.046
18.	ALMC220917xZ			0.958	0.052												