INSTITUT FÜR SOLARTECHNIK

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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 robust Al
Description:	Selective solar absorber: PVD coating with protection and antireflection layer based on oxide ceramic / cermet absorber multilayer / adhesion layer / aluminium substrate
Start of test:	December 2021
Completion of test:	May 2022
Expiration date:	May 2027 (The test result is no longer valid after substantial changes of the coating or substrate)

The test material has passed **part A (stability with regards to high temperature)** of the test according to ISO/EN 22975-3 and 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 as-received samples have been measured in order to determine the temperature for pre-conditioning by the use of 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	0.932	0.932	0.932	**0.932**
Emittance, ε_{100}	0.030	0.032	0.033	**0.032**
Temperature to be applied for pre-conditioning of the samples				**214°C**

Qualification for testing

In total, 18 samples have been pre-conditioned by tempering for 5 hours at the temperature given in Table 1. The optical properties after tempering were determined and they are presented in Table 2. The value of the solar absorptance and thermal emittance was calculated as specified in clause 5.3 and 5.4 from ISO/EN 22975-3.

Table 2: Mean values of the optical properties of 18 samples after pre-conditioning

	Solar absorptance, α_s	Emittance, ε_{100}
Mean value	0.932	0.034
Standard deviation	0.001	0.002
Minimum value	0.930	0.030
Maximum value	0.935	0.037

After pre-conditioning, an adhesion test according to ISO 2409 (for soft samples) has been applied to three of the samples. The results are presented in Table 3.

Table 3: 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

According to clause 4.2 and 4.3 of the ISO 22975-3 standard, the test specimens are <u>qualified for testing</u>. The standard deviation for solar absorptance and thermal emittance is less than 0.01 and 0.04, respectively, and as the adhesion test of the three samples was leading to a result grade ≤ 1 (Table 3).

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

	Temperature [°C]
maximum absorber surface temperature T_{max}	214
first testing temperature T_1	291

Tests for assessing the thermal stability of absorber surfaces

According clause 6.4.3 of the 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 optical properties determined after 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	0.001	-0.002	0.000	-0.001	-0.005	-0.004

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 was leading 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, May 2022

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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 temperatures were measured with a calibrated (±1 K) Pt-100 sensor.

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Detailed results

Nr.	Sample code	Reference		5h @ 215°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.	ALMR211200xZ	0.932	0.030	0.931	0.032												
2.	ALMR211201xZ	0.932	0.032	0.931	0.034												
3.	ALMR211202xZ	0.932	0.033	0.931	0.033												
4.	ALMR211203xZ			0.935	0.031												
5.	ALMR211204xZ			0.931	0.032												
6.	ALMR211205xZ			0.933	0.030												
7.	ALMR211206xZ			0.930	0.031	0.934	0.042	0.936	0.041	0.934	0.041	0.936	0.042	0.936	0.033	0.935	0.034
8.	ALMR211207xZ			0.931	0.035	0.933	0.041	0.937	0.042	0.934	0.040	0.936	0.042	0.936	0.033	0.935	0.033
9.	ALMR211208xZ			0.933	0.033	0.936	0.041	0.940	0.040	0.937	0.040	0.939	0.042	0.939	0.034	0.938	0.033
10.	ALMR211209xZ			0.930	0.035												
11.	ALMR211210xZ			0.930	0.035												
12.	ALMR211211xZ			0.931	0.035												
13.	ALMR211212xZ			0.933	0.036												
14.	ALMR211213xZ			0.931	0.035												
15.	ALMR211214xZ			0.932	0.037												
16.	ALMR211215xZ			0.933	0.035												
17.	ALMR211216xZ			0.932	0.035												
18.	ALMR211217xZ			0.931	0.034												