Advanced cyclic accelerated aging testing of solar reflector materials

Johannes Wette[1], Florian Sutter[1], Mai Tu[1], Aránzazu Fernández-García[2], Francisco Buendia[2], M. João Carvalho[3] and Teresa Diamantino[3]

[1] DLR, German Aerospace Center, Institute of Solar Research, Plataforma Solar de Almería, Ctra. Senés Km. 4, P.O. Box 39, E04200, Tabernas, Almería (Spain), E-mail address: Johannes.Wette@dlr.de

[2] CIEMAT Plataforma Solar de Almería, Ctra. Senés Km. 4, P.O. Box 22, E04200, Tabernas, Almería (Spain)

[3] LNEG. - Laboratório Nacional de Energia e Geologia, Estrada do Paço do Lumiar, 22, 1649-038 Lisboa, Portugal

1. Introduction

Lifetime prediction methods for the components of concentrated solar power (CSP) plants have been in the focus of interest of manufacturers and plant developers for the past years. Recently, an accelerated aging standard for solar mirrors was published by the Spanish AENOR committee [1]. This standard allows performing comparative testing but it is not suited to derive meaningful life-time estimations. Firstly, the testing defined in the standard is not aggressive enough to produce significant degradation on most of the materials and secondly, it has been shown that the passing of these tests does not guarantee a high durability during outdoor exposure [2]. These findings have proven the need for the investigation of more realistic procedures. To provoke the mechanisms that are detected during outdoor exposure, a more realistic application of environmental stresses is being investigated. In this work a series of tests is conducted in which several weathering stresses are combined and applied in a cyclic manner. Some of these cycles have shown to correlate better with real outdoor behavior.

2. Methodology

To find a suitable test procedure, a high number of different cycles were conducted to analyze the influence of the testing parameters. Three differently coated glass mirror materials (A, B, C) were chosen for the campaign performed at OPAC laboratory (a joint research group between DLR and CIEMAT at the PSA) and LNEG, which at the same time are also exposed on different outdoor sites. 14 different test cycles were conducted, combining the following standard tests: UV/Humidity (UVH), copper accelerated salt spray (CASS), neutral salt spray (NSS), damp heat (DH) and combination of H_2S, NO_2 and SO_2 (GAS). The detailed parameters of the tests are presented in [3]. The cycles differ in the combination of the standard tests and the frequency and duration of the single tests, which include drying phases with storage at normal laboratory conditions. Test 11 and 13 were conducted with samples that had been exposed in an outdoor exposure setup with concentrated radiation for half a year before conducting the cycles. In Fig. 1 the different cycles are represented.

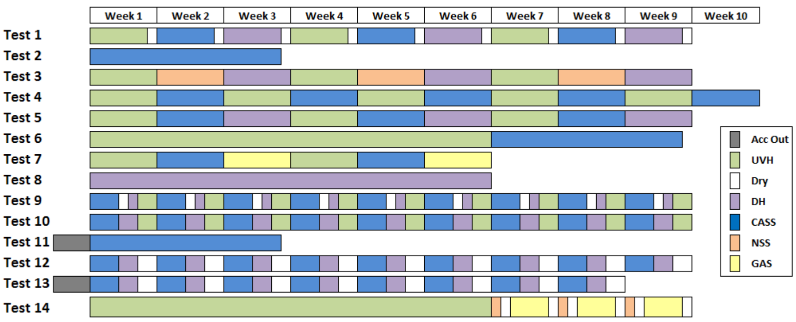


Figure 1: composition and frequency of cycles conducted during the durability test campaign

After completion of each cycle the samples were optically analyzed. Photographs of the front and back surface were taken and the degradation parameters were determined.

3. Results and discussion

The degradation of the samples differs strongly among materials and cycles. Test T4 (weekly cycles of UVH and CASS) shows to be the most aggressive for the tested materials. In Fig. 2, the development of the reflectance and the number of corrosion spots in the silver layer for material C are displayed, as an example. For this material both the reflectance drop and the number of corrosion spots are the highest in this test. The tendency is the same for the other materials studied.

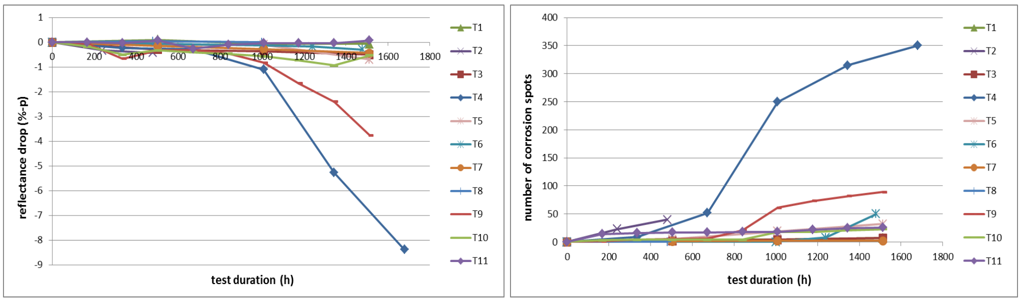
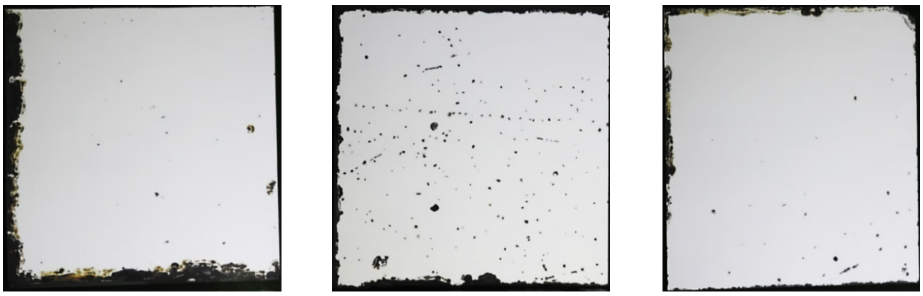


Figure 2: reflectance drop and corrosion spot development of material C during the different test cycles

For material C, photographic images of the reflective surface are displayed in Fig. 3 for three different cycles. The duration the different samples were subjected to the CASS conditions, was roughly 500 h in all of the three cases. The degradation on the surface is considerably stronger for the case of T4. The analysis of the different cycles is important to confirm the appearance of realistic degradation mechanisms and in the end select adequate tests for a suitable lifetime prediction procedure.



a) b) c)

Figure 3: surface of material C after a) 480 h of pure CASS testing T2, b) 1008 h of T4 and c) 1480 h of T6

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References

[1] UNE206016-2018, Paneles reflectantes para tecnologías de concentración solar, AENOR: Madrid, España, 2018.

[2] J. Wette, F. Sutter, A. Fernández-García, R. Lahlou, P. Armstrong, Standardizing Accelerated Aging Testing Conditions for Silvered-Glass Reflectors, SolarPACES 2017, Santiago de Chile (Chile), 26-29 September 2017.

[3] F. Sutter, A. Fernandez-García, J. Wette, P. Heller, Accelerated Aging Testing Program For Solar Reflectors, Energy Procedia, 2013.