Abrasion Resistant Coating

The mirrors of a concentrating solar power plant must have **high specular reflectance** for their entire lifetime in order to direct as much sunlight as possible onto the receivers. Specular reflectance can be degraded by abrasion during cleaning if scrub brushes or other mechanical devices are used. An **abrasion resistant coating protects** the specular reflectance of the mirror surface.

ReflecTech, Inc. and the National Renewable Energy Laboratory (NREL) are collaborating on the development and manufacturing validation of an abrasion resistant coating (ARC) that will be available as a topcoat on ReflecTech® Mirror Film by the end of 2011. The ReflecTech®ARC is recommended when reflectors are washed using scrub brushes, or other mechanically aggressive cleaning methods which can scratch the surface of polymer reflectors and reduce specular reflectance. Details of the development process are documented in a paper [1] presented at the Solar PACES conference in 2010.

Testing Summary

Samples of the ReflecTech®ARC were exposed to the types of conditions expected in service, in terms of both weathering and contact cleaning. Weathering is simulated by exposure to concentrated ultraviolet (UV) radiation and elevated temperature and humidity. Specular reflectance after exposure was measured to determine performance of the ARC under the various accelerated stress conditions, and outstanding abrasion resistance was demonstrated.

Abrasion Resistance – Scrub Test

To simulate the most aggressive solar field mirror cleaning process, ASTM D2486 [3] was performed with a Byk Model PB5005 wet abrasion scrub tester. This test uses linearly articulated scrub brushes cycled in a back-and-forth motion 37 times per minute across the surface of ReflecTech®ARC. Figure 1 illustrates that no loss in specular reflectance occurred after over 50,000 back-and-forth scrub brush cycles, simulating more than 50 years of wear.

Abrasion Resistance – Taber Abraser

A Taber abraser unit was used to apply abrasive stress (ASTM D4060 [2]), and a Devices and Services Specular Reflectometer was used to monitor optical performance as a function of the number of cycles. Taber abrasion is a severe stress compared to the cleaning used in solar fields, and is used here only as a protocol to guide the ARC development process. Figure 2 illustrates that there is no loss in specular reflectance after 10 and 30 Taber abraser cycles on samples of ReflecTech®ARC.

Abrasion Resistance – Scrub Test

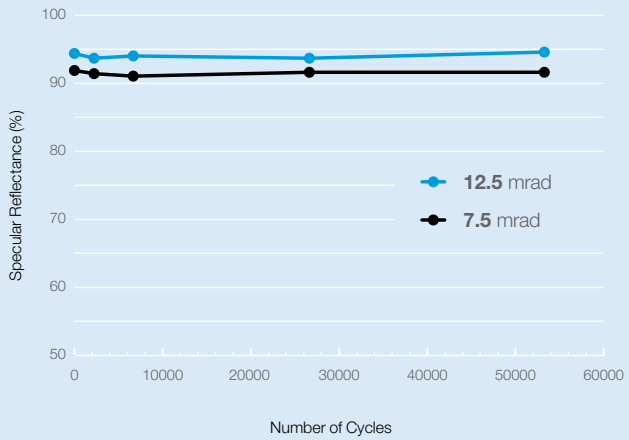

Figure 1. Abrasion resistance of ARC- ReflecTech® in terms of scrub brush cycles. Specular reflectance was measured at **660 nm**, and **θ = 7.5** and **12.5 mrad** half acceptance angles.

Abrasion Resistance – Taber Abraser

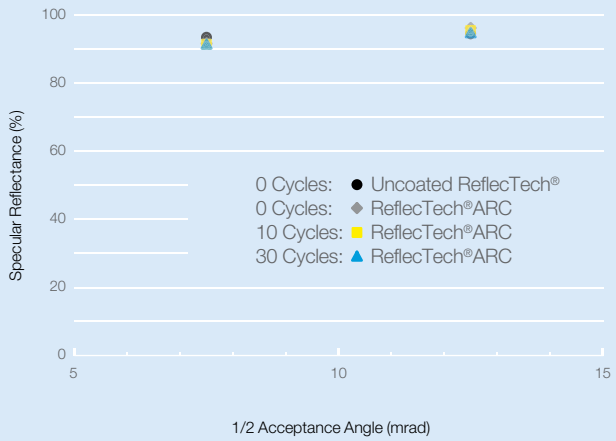

Figure 2. Abrasion resistance of ReflecTech®ARC in terms of Taber abraser cycles with 250 g arm weight. Specular reflectance was measured at **660 nm**, and **θ = 7.5** and **12.5 mrad** half acceptance angles.

UV Resistance - UAWS

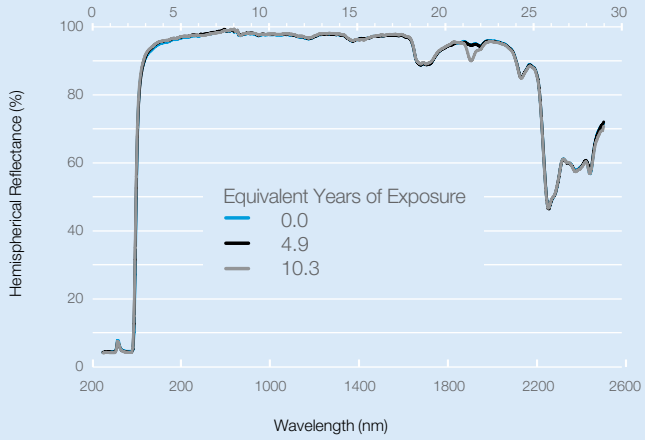

Figure 3. Spectral hemispherical reflectance of ReflecTech®ARC samples after **0 (initial)**, **4.9**, **and 10.3 years**' equivalent UV exposure in NREL's UAWS. Samples exposed at 30°C.

UV Resistance

Figure 3 illustrates the outstanding UV resistance of the ReflecTech®ARC material. After the equivalent of over 10 years UV exposure in NREL's Ultra Accelerated Weathering System (UAWS, described in [4]) there is no significant spectral loss in hemispherical reflectance.

Adhesion

Adhesion of the ARC to the ReflecTech® Mirror Film was measured before and after weathering using ASTM D3359 cross-hatch tape peel test [5] – there was no loss of adhesion.

Resistance to Moisture

Samples of ReflecTech®ARC laminated to aluminum panels were immersed in deionized water for 30 days. There was no sign of delamination at any layer interface. The cross hatch tape peel test was also performed after immersion, and there was no loss of adhesion.

Conclusions

The ReflecTech®ARC has demonstrated excellent abrasion resistance, adhesion, and weatherability. Resistance to Taber abrasion is maintained after exposure to UV light, condensation cycling, and thermal cycling. Commercial introduction of ReflecTech®ARC is anticipated toward the end of 2011.

References:

(1) **Gary Jorgensen, Randy Gee, and Michael DiGrazia,** *"Development and Testing of Abrasion Resistant Hard Coats for Polymer Film Reflectors"*, Solar PACES, 2010.

(2) ASTM D4060, "Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser", American Society of Testing and Materials Annual Book of Standards, Vol. 06.01, ASTM International, West Conshohocken, PA, www.astm.org.

(3) ASTM D2486, "Standard Test Methods for Scrub Resistance of Wall Paints", American Society of Testing and Materials Annual Book of Standards, Vol. 06.02, ASTM International, West Conshohocken, PA, www.astm.org.

(4) **H. K. Hardcastle, G. J. Jorgensen, and C. E. Bingham**, "Ultra-Accelerated Weathering System I: Design and Functional Considerations", *Natural and Artificial Ageing of Polymers – 4th European Weathering Symposium*; Reichert, T., Ed. Publication No. 11, Gesellschaft fur Umweltsimulation: Germany, 2009.

(5) ASTM D3359, "Standard Test Methods for Measuring Adhesion by Tape Test", American Society of Testing and Materials Annual Book of Standards, Vol. 06.01, ASTM International, West Conshohocken, PA, www.astm.org.

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