"ReflecTech polymer film is a viable alternate to glass mirrors, offers comparable performance and durability, and is not susceptible to breakage as are glass mirrors."

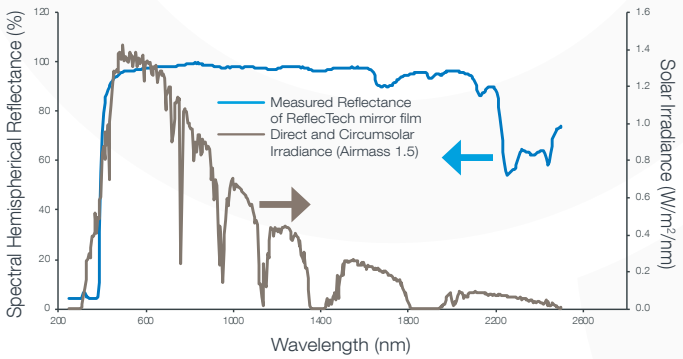
Sargent & Lundy, LLC

ReflecTech®

Mirror Film

ReflecTech® mirror film is a breakthrough technology for solar concentrators. It has the same reflectance as the glass mirrors used in previous generation systems but is lighter weight, lower cost and totally unbreakable, improving the economics of the solar concentrators of the future. ReflecTech mirror film has been proven to maintain its reflectance for decades, even in the harshest outdoor environments in the world.

SPECTRAL HEMISPHERICAL REFLECTANCE



FEATURES

- High Reflectance
- Outdoor Weatherable
- Ultra-Lightweight
- Abrasion Resistant
- Commercially Proven
- Low Cost
- Self-Adhesive

ReflecTech mirror film has high reflectance in the wavelength range important for harnessing sunlight for thermal generation. Hemispherical reflectance is plotted on the left axis while the terrestrial irradiance of sunlight is plotted on the right axis, both as functions of wavelength. The specular reflectance is 94 %.

SkyFuel®

Simply Brilliant™

REFLECTECH® MIRROR FILM – BUILT ON COLLABORATION

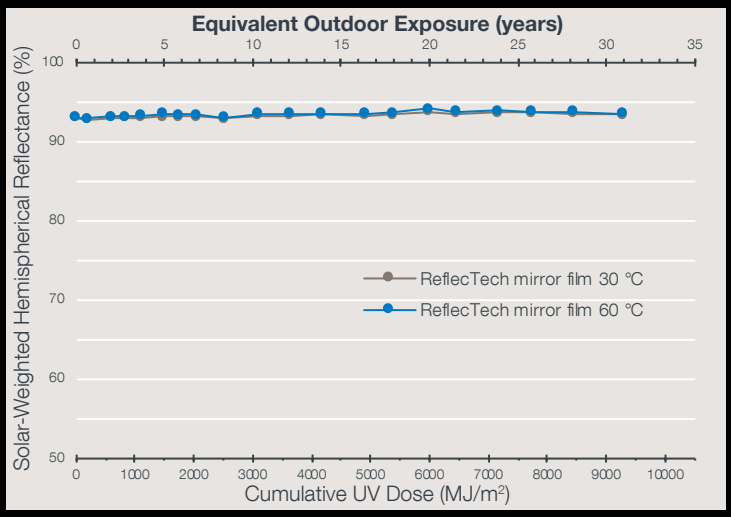
ReflecTech mirror film was collaboratively developed by SkyFuel and the National Renewable Energy Laboratory (NREL) in the USA through an industry-leading public/private partnership. The result is a technology that is proven, reliable and guaranteed to improve the economics of solar concentrators. (US Patents 6,989,924 and 7,612,937)

ReflecTech mirror film uses pure silver to provide high specular reflectance and multiple layers of polymer films to protect against extreme outdoor environments including ultra-violet (UV) radiation and moisture. In addition, a tough, transparent coating protects the film against abrasion. The result is the most advanced reflective surface in the world.

EXCELLENT OUTDOOR WEATHERABILITY

ReflecTech mirror film has undergone extensive outdoor durability testing using the Ultra-Accelerated Weathering System (UAWS) at NREL. UAWS is an accelerated method to determine the long-term durability of a material to outdoor UV exposure. The UV portion of natural sunlight is concentrated 100X while sample exposure temperatures are maintained at 30 °C and 60 °C to accelerate degradation mechanisms.[2]

ReflecTech mirror film passed the 30-year milestone during a long-term UAWS durability test. The test results indicated almost no reflectance reduction.



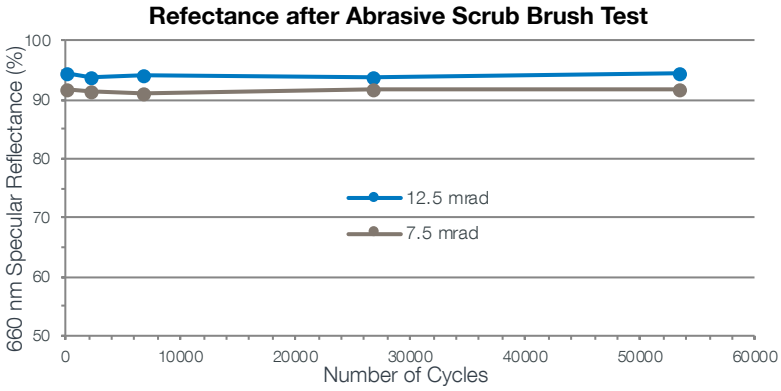
MOISTURE RESISTANCE

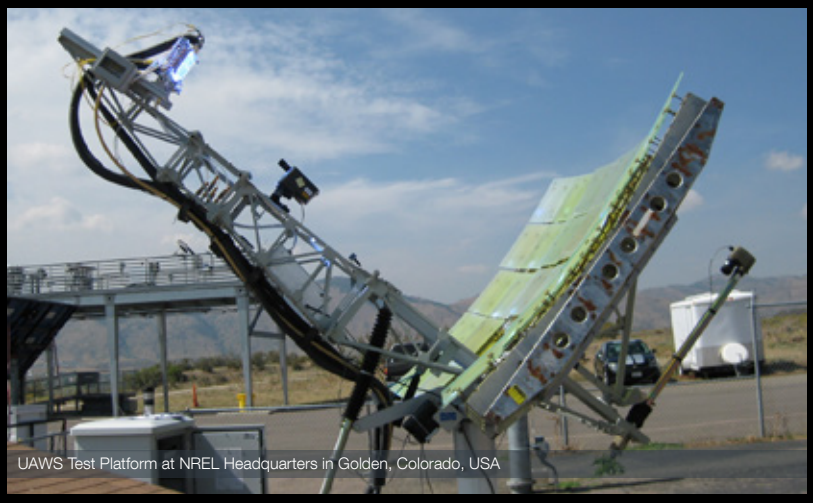
ReflecTech mirror film laminated metal substrate panels were immersed in deionized water for 30 days at NREL (ASTM D3359). There was no sign of delamination at any layer interface. In addition, the cross-hatch tape peel test was also performed after immersion, and there was no loss of adhesion.

ReflecTech Mirror Film

TESTED ABOVE AND BEYOND **PASSING** WITH FLYING COLORS

- UV | Temperature | Moisture Test (ASTM G 155): 2 X UV | 30 °C & 60 °C | 5 % & 60 % Relative Humidity: 12,000 hours - **pass**
- Outdoor Test (ASTM G 90) 5 X sunlight & hourly water spray: 7,500 hours - **pass**
- Water Resistance Test (ASTM D 870) 30 days of immersion - **pass**
- Cyclic Condensation (ASTM D 4587): 100 % relative humidity | 30 °C & 60 °C: 100 cycles - **pass**
- Taber Abrasion (ASTM D 4060) | 30 cycles before and after weathering - **pass**
- Adhesion of Coating (ASTM D3359) | Cross hatch tape peel test before and after weathering - **pass**
- Bending Test (ASTM D 522) @ 25 mm radius and above - **pass**
- Hail Test (ASTM E 822) front and back, 1” diameter - **pass**
- Falling Sand Abrasion (ASTM D 968) | 2 liters of 120 grit sand - **pass**
- Thermal Cycling for Coatings (ASTM D 6944, Method B): 30 cycles - **pass**
- Humidity Freeze Testing (IEC 62108, Section 10-8): -40 °C to 60 °C, ambient to 83 % relative humidity: 10 cycles - **pass**
- Corrosion Testing, Salt Spray (Fog) (ASTM B 117): additional edge treatment, 500 hr - **pass**

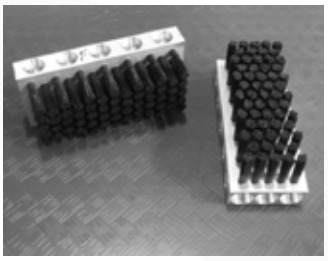



UAWS Test Platform at NREL Headquarters in Golden, Colorado, USA

ABRASION RESISTANCE

Collaboratively developed[1] by SkyFuel and NREL, ReflecTech mirror film's unique tough, transparent coating maintains its optical efficiency even under abrasive circumstances, including regular cleaning maintenance and / or sand storms.

To simulate the most aggressive solar field mirror cleaning process, ASTM D2486[3] was performed with a BYK Model PB 5005 wet abrasion scrub tester. This test uses linearly actuated scrub brushes cycled in a back-and-forth motion 37 times per minute across the surface of ReflecTech mirror film. The figure illustrates that no loss in specular reflectance occurred after over 50,000 back-and-forth scrub brush cycles, simulating more than 50 years of routine scrub cleaning.




ReflecTech mirror film used within the advanced SkyTrough collector

CONCLUSION

After more than 15 years of continuous use in commercial applications, ReflecTech mirror film has become a proven and reliable reflective surface that is revolutionizing solar concentrators. It is the most tested reflective surface in the Concentrated Solar Power industry and is guaranteed to last for decades in harsh outdoor environments. By surviving the extreme conditions found in typical solar projects such as heat, cold, humidity, wind, sand, hail and UV exposure, ReflecTech mirror film has demonstrated superior long-term performance over glass-based alternatives.

ReflecTech mirror film also enables innovative new solar concentrator designs that will dramatically reduce the cost of future solar projects and create a path towards a large scale-up of the CSP industry.

REFERENCES:

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

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

(3) American Society of Testing and Materials (ASTM) Annual Book of Standards, ASTM International, West Conshohocken, PA, www.astm.org

SkyFuel

ReflecTech® Mirror Film Specifications

PERFORMANCE CHARACTERISTICS

Specular Reflectance[4]	94.0 %	At 12.5 mrad, 660 nm
Solar-Weighted Hemispherical Reflectance[5]	92.5 %	ASTM G173

(4) Measured on Devices & Services 15R Specular Reflectometer
(5) Integrated over Direct Normal air mass 1.5 solar spectrum

PRODUCT / PHYSICAL CHARACTERISTICS

Nominal Thickness	0.1 mm		
Coefficient of Thermal Expansion	5.5 x 10-5 cm/cm/°C		ASTM E831
	Machine Direction	Transverse Direction	
Tensile Strength	61 MPa	64 MPa	ASTM D882
Elongation at Break	88 %	72 %	ASTM D882
Yield Strength at 2 % Offset	40 MPa	36 MPa	ASTM D882
Yield Elongation at 2 % Offset	4.7 %	4.6 %	ASTM D882
Modulus	1430 MPa	1566 MPa	ASTM D882

APPLICATIONS CHARACTERISTICS

Adhesion to Aluminum[6] 180° Peel Strength	10.0 N/25 mm	ASTM D903

(6) Adhesion depends on the cleanliness and nature of the surface. The indicated values are for reference only.

OPERATION

Maximum Operating Temperature	60 °C	*140 °F*
Cleaning	Pressure wash with de-mineralized water	

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