Towards standardized testing methodologies for optical properties of components in concentrating solar thermal power plants

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INTRODUCTION

Precise knowledge of the **optical properties** of the components used in the solar field of concentrating solar thermal power plants is primordial to ensure their optimum power production.

Those properties are measured and evaluated by **different techniques and equipment**, in laboratory conditions and/or in the field. **Standards** for such measurements and international consensus for the appropriate techniques are in **preparation**.

The reference materials used as a standard for the calibration of the equipment are under discussion. This paper summarizes current testing methodologies and guidelines for the characterization of optical properties of solar mirrors and absorbers.

STANDARDIZATION COMMITTEES

- Spain: sub-committee **AEN/CTN 206/SC117** "thermoelectric solar energy systems" since 2010.
- International: **IEC TC 117** committee "Solar thermal electric plants" since 2012
- In the photovoltaic (PV) sector, existing standards, including ISO and ASTM, applicable to optical properties measurements.
- In other sectors, some standards applicable to determine glass optical properties for solar radiation (ISO 9050, EN 410, ISO 13468-2, ISO 17223)

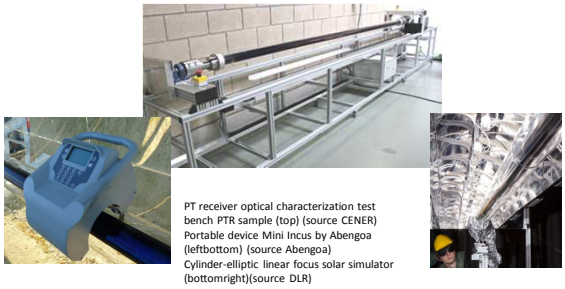
SOLAR REFLECTORS

- Reflectors group within **SolarPACES task III**: published a **guideline** dealing with the hemispherical and specular reflectance.
- **Hemispherical spectral reflectance** measured with a spectrophotometer with integrating sphere at near normal incidence (θi ≤ 15º) (wavelength range from 280 nm to 2500 nm).
- **Specular reflectance**: different commercial devices have been applied and reported (*Devices & Services* model 15R, *Abengoa* model Condor, *Surface Optics*). **New prototype devices** are published (*VLABS* by Fraunhofer ISE, *SQM* by ENEA, a new instrument by the University of Zaragoza, *MIRA*, *(SR)2* and *S2R* by DLR, …).

Perkin Elmer Lambda 1050 spectrophotometer (topleft) and D&S 15R SSR reflectometer (topright) (source DLR/CIEMAT)
Optronics Laboratories OL 750 spectrophotometer (bottomleft) and Condor reflectometer (bottomright) (source CENER)

SOLAR RECEIVERS

- In Spain: AEN/CTN 206/SC 117/WG2 standard draft under progress and international **IEC prIEC 62862-3-3**.
- Two different testing methodologies : **destructive and non-destructive tests**
- **PSA:** destructive test with spectroradiometer on small samples
- **CENER:** no destructive testing bench (glass envelope solar transmittance and absorber solar reflectance for wavelength range from 300 nm to 2500 nm)
- **Abengoa:** portable no destructive measurement in field (14 wavelengths, between 365 and 1950 nm)
- **DLR:** no destructive solar simulator optical testing bench for the overall optical efficiency, $\tau * \alpha$ product,



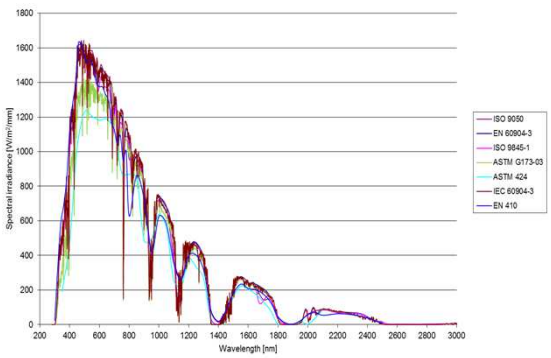
PT receiver optical characterization test bench PTR sample (top) (source CENER)
Portable device Mini Incus by Abengoa (leftbottom) (source Abengoa)
Cylinder-elliptic linear focus solar simulator (bottomright)(source DLR)

SOLAR SPECTRUM

- Calculation of solar properties from optical measurements:

$$\alpha_s = \frac{\sum_{\lambda_1}^{\lambda_2}(1-\rho(\lambda_i))E(\lambda_i)\Delta\lambda_i}{\sum_{\lambda_1}^{\lambda_2}E(\lambda_i)\Delta\lambda_i} \qquad \tau_s = \frac{\sum_{\lambda_1}^{\lambda_2}\tau(\lambda_i)E(\lambda_i)\Delta\lambda_i}{\sum_{\lambda_1}^{\lambda_2}E(\lambda_i)\Delta\lambda_i}$$

- Differents standard from the spectrum distribution (ISO 9845-1, ISO 9050, IEC 60904-3, ASTM E 424 - 71, ASTM G173-03, EN 410) with different AM and wavelength range.



CONCLUSIONS

- Methods are already widely used and round robin tests aim at international agreements on the methods. Guidelines and standards are in advanced stage.