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"Solar Absorptance, Reflectance and Transmittance of Materials"

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These are preliminary lecture notes, intended only for distribution to participants.

SOLAR ABSORPTANCE, REFLECTANCE, AND TRANSMITTANCE OF MATERIALS

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SUMMARY

A Large Multipurpose, Solar-Illuminated 8 Foot Integrating (LMPI) sphere, designed and developed by the DSET Laboratories, Phoenix, Arizona,USA, determines the solar optical properties in a precise and convenient manner. The sphere was installed at the Solar Village near Riyadh. Its description and usefulness are presented in this paper.

INTRODUCTION

Solar energy absorptance, reflectance, and transmittance are important in the performance of all solar energy systems ranging from passive buildings to central power stations. Absorptance, α, is the ratio of the absorbed radiant flux to the incident radiant flux. Reflectance, ρ, is the ratio of the reflected radiant flux to the incident radiant flux. Transmittance, τ, is the ratio of the transmitted radiant flux to the incident radiant flux. Kirchoff relationship gives,

$$\alpha + \tau + \rho = 1$$

For opaque materials, $\tau = 0$, and hence $\alpha + \rho = 1$

For non-opaque materials, $\alpha = 1 - (\tau + \rho)$

Solar optical properties, α, ρ, and τ, (300 nm - 3000 nm) can be determined by an integrating sphere, which is an optical device used to either collect flux reflected or transmitted from a sample into a hemisphere. It consists of a cavity that is approximately spherical in shape with apertures for admitting and detecting flux [1].

LMPI SPHERE

DSET Laboratories constructed a Large, Multipurpose, Solar-Illuminated 8 Foot Integrating (LMPI) sphere, and installed it at the Solar Village near Riyadh under the SOLERAS program. The 8 Foot sphere is of polyester fiberglass construction mounted on a steel movable frame. SOLERAS program is an excellent research endeavour between the United States of America and Saudi

Arabia in the field of solar energy.

An automatic tracking solar siderostat focuses the sun's rays onto a fixed mirror, which in turn focuses the direct beam component of the sun through a building entrance port. The siderostat is a eight-faceted mirror assembly that tracks both in azimuth and in elevation by using solid-state tracking system [2]. The outside fixed mirror is mamually adjusted as needed to keep the sun's direct beam in line with the building entrance port. By either placing the test specimen in the port opening or inside the sphere,the optical properties of the specimen can be measured. Incident angles can range from -60 to +60 degrees. A photometric sensor (Li-Cor Model LI-210SA) is employed to measure the visible light and as such its spectral response curve is equal to that of a human eye. A thermopile detector is used for total solar irradiance(Oriel Model 7102, spectral response is from 300 nm to 3000 nm).

PROCEDURE

Transmittance measurement: (see Figure 1)

Cover aperture opening and record 'dark voltage' (VD). Dark voltage is the detector output under zero irradiance condition.

Open aperture and record total incoming voltage (VT).

Place sample in front of opening and record voltage (VS).

$$\tau = \frac{VS - VD}{VT - VD}$$

Reflectance measurement: (see Figure 2)

Place specimen in centre of the sphere

Adjust aperture opening so that the light beam is within the perimeter of the specimen.

Adjust sphere angle such that the specimen's reflection stays within the sphere's walls.

Place detector such that it is not in the direct path of the reflected light.

Cover sphere's aperture opening and record VD.

Uncover aperture opening and push stantion until specimen is in the centre of the beam.

Record voltage with specimen in the beam (VS)

Pull stantion outward until specimen is completely out of beam.

Record voltage with specimen in the sphere, but out of the beam (VT)

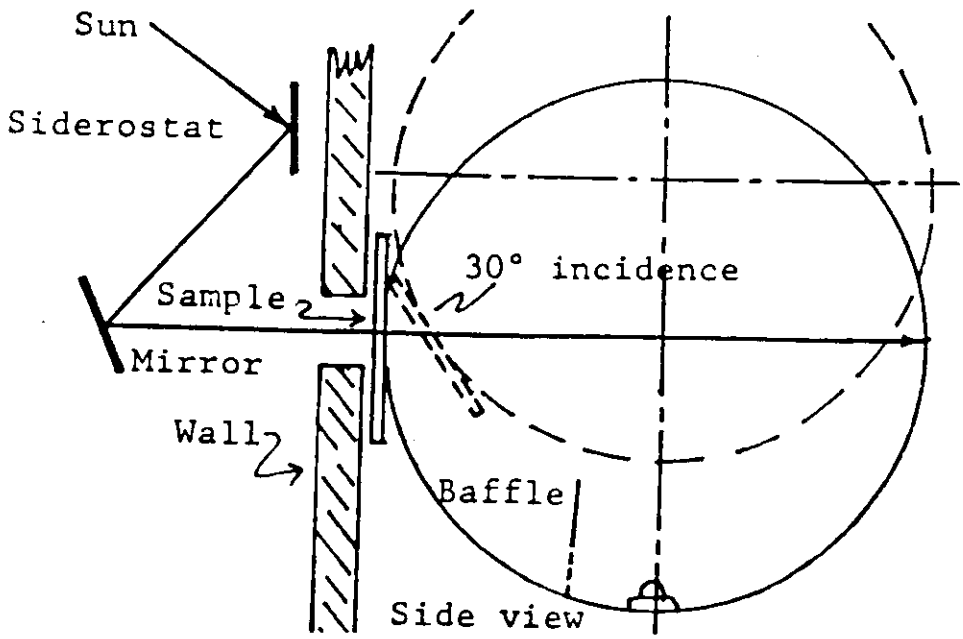

Figure 1. LMPI Sphere Transmittance Mode

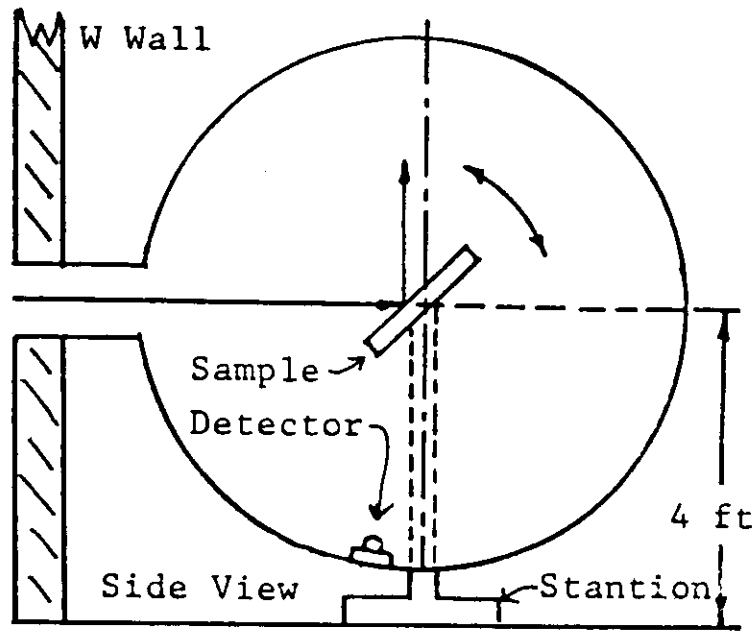

Figure 2. LMPI Sphere Reflectance Mode

$$(\tau + \rho) = \frac{VS - VD}{VT - VD}$$

$$\alpha = 1 - (\tau + \rho)$$

$$\rho = 1 - \tau - \alpha$$

REFERENCES

1. Annual Book of ASTM Standards

2. DSET Laboratories Document No.87RO112-LS