Dipartimento di Ingegneria Meccanica e Civile
Università di Modena e Reggio Emilia

# $E^2L_{ab}$

## *Energy Efficiency Laboratory*

**Object:** laboratory measurement on alkorPLAN 35276

**Client:** RENOLIT Italia Srl

**Reference person:** Prof. Paolo Tartarini

**Work start:** 01/08/2008

**Work completion:** (after receipt of the weathered samples)

**Notes:** Preliminary Report

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## 1. Object of the work

The activity was aimed at measuring the performance of a product for building covering distributed by RENOLIT Italia Srl at Buriasco (TO).

The product under investigation is a waterproofing membrane for low-slope roofs made of PVC and identified by the trade name AlkorPlan 35276, colored in mass in order to obtain a brilliant white appearance.

The analysis was divided into the following steps:

- Measurement of the solar reflectance of the surface exposed to the external ambient, performed through analysis of no. 4 flat square samples with size 50 mm x 50 mm, prepared by the client. The spectral reflectivity was preliminarily measured in the band of interest for solar radiation (between 280 nm and 2500 nm) by means of a UV-V-NIR spectrophotometer. The solar reflectance was then evaluated as the average of the spectral reflectivity in the range of measurement, weighed on the solar radiation spectrum at the Earth's surface as reported in the ASTM Standard G173.
- Measurement of the thermal emittance of the surface exposed to the external ambient, performed on the same samples mentioned above. The thermal emittance was measured by means of a emissometer based on the ASTM Standard C1371.

Brand new samples were analyzed up to now. Weathered samples shall be also tested after completion of the weathering process and delivery.

## 2. Measurement methods

Regulatory requirements have not yet been emitted in Italy about the characterization of radiative properties of building surfaces relevant to their response to the solar cycle. Therefore, measurement methods suggested by the most important organization of the field, the Cool Roof Rating Council (www.coolroofs.org), were used. The procedures defined by the Cool Roof Rating Council are legally recognized by the main standardization bodies in the USA (DoE / EPA, State and local governments) and are widely used to test products commercialized in the U.S. market.

An UV-V-NIR spectrometer with integrating sphere was used to measure the spectral reflectivity $\rho_\lambda$ of the samples, according to the ASTM Standard E-903 (*Standard Test Method for Solar Absorptance*). The instrument measures the reflection of the radiation produced by two automatically selected lamps at several wavelengths. More specifically, the spectral reflectivity was measured at 1'111 evenly spaced wavelengths in the range from 280 nm to 2500 nm, which includes more than 99% of solar radiation at the Earth surface (Fig. 2.1). The solar reflectance $R$ of the analysed surface was then calculated by integrating over the defined range the measured spectral reflectivity $\rho_\lambda$, weighted by the spectral irradiance of the sun at the Earth surface, $I_\lambda$ [W/(m$^2$nm)], as obtained from the ASTM Standard G173 (*Standard Tables for Reference Solar Spectral Irradiances*).

$$R = \frac{\int_{280}^{2500} \rho_\lambda(\lambda) \cdot I_\lambda(\lambda) \cdot d\lambda}{\int_{280}^{2500} I_\lambda(\lambda) \cdot d\lambda} \qquad (2.1)$$

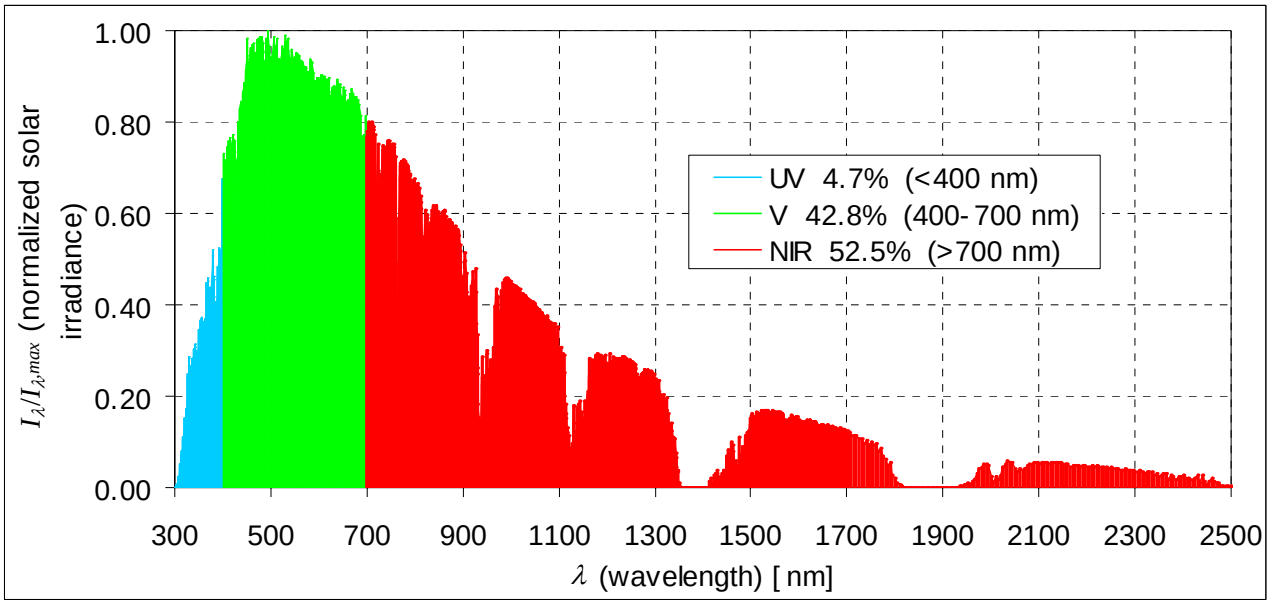


Figure 2.1. Normalized solar radiation spectrum at the Earth's surface (data from ASTM Standard G173).

The thermal emittance, $E$, was measured by means of an emissometer based on the ASTM Standard C1371 (*Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometer*). The instrument measures the total hemispherical emittance of the sample through the following relationship:

$$\Delta V = k \cdot \frac{\sigma_0 \cdot \left(T_d^4 - T^4\right)}{\frac{1}{E} + \frac{1}{E_d} - 1} \tag{2.2}$$

In Eq. (2.2), the voltage signal $\Delta V$ [V] returned by the instrument is proportional by a calibration constant $k$ to the heat flux exchanged between the surface of the sample, having thermal emittance $E$ (unknown) and absolute thermodynamic temperature

stabilized at a value $T$ [K] as close as possible to the ambient one, and an area of the instrument characterized by known thermal emittance $E_d$ and absolute thermodynamic temperature stabilized at an assigned value $T_d$ [K] ($> T$). The heat flux is evaluated from the analytical solution for two infinite flat surfaces facing each other, assumed to be gray and diffusive.

The thermal emittance of the sample is obtained solving Eq. (2.2) (which also contains the Stefan-Boltzmann constant $\sigma_0$=5.67·10$^{-8}$ W·m$^{-2}$·K$^{-4}$) with respect to $E$.

The emissometer is calibrated before each test by measuring two different samples with known emittance. The producer ensures the linearity of the instrument and uncertainty ±0.01 in the whole range $0.03 \le E \le 0.93$.

If the sample shows a non negligible resistance to heat transfer, the heat input applied to the measured surface by the emissometer and released to the ambient at the opposite surface causes a temperature gradient across the thickness. As a result, the temperature at the measured surface rises to a value higher than the ambient one. This requires a proper correction of the thermal emittance $E_m$ returned by the emissometer.

$$E = E_m + \Delta E \tag{2.3}$$

Explanation about the correction procedure is omitted here for sake of conciseness.

## 3. Measurements on new samples

The analysis was carried out on new production samples, prepared by the client in the form of flat squares with size 50 mm x 50 mm, 1.5 mm thick.
The results in terms of thermal emittance are reported in Tab. 3.1.

Table 3.1.

Measured and corrected thermal emittance, $E_m$ and $E$ ($T_{ambient}$ = 27°C).

| Sample | 1 | 2 | 3 | 4 | Mean |
|---|---|---|---|---|---|
| Thermal emittance $E_m$ | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 |
| Thermal emittance $E$ | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |

The correction applied to the measured emittance $E_m$ in order to obtain the corrected emittance E was calculated assuming the thermal conductivity of the measured material equal to 0.14 W/(m·K). This is the value reported for PVC membranes by the European rule EN 12524 (*Building materials and products – Hygrothermal properties – Tabulated design values*).

The results in terms of solar reflectance are reported in Tab. 3.2 and Figs. 3.1-3.2.

Table 3.2.

Measured solar reflectance ($T_{ambient}$ = 29.5°C).

| Sample | 1 | 2 | 3 | 4 | Mean |
|---|---|---|---|---|---|
| Solar reflectance $R$ | 90.2% | 90.2% | 90.6% | 91.1% | 90.5% |

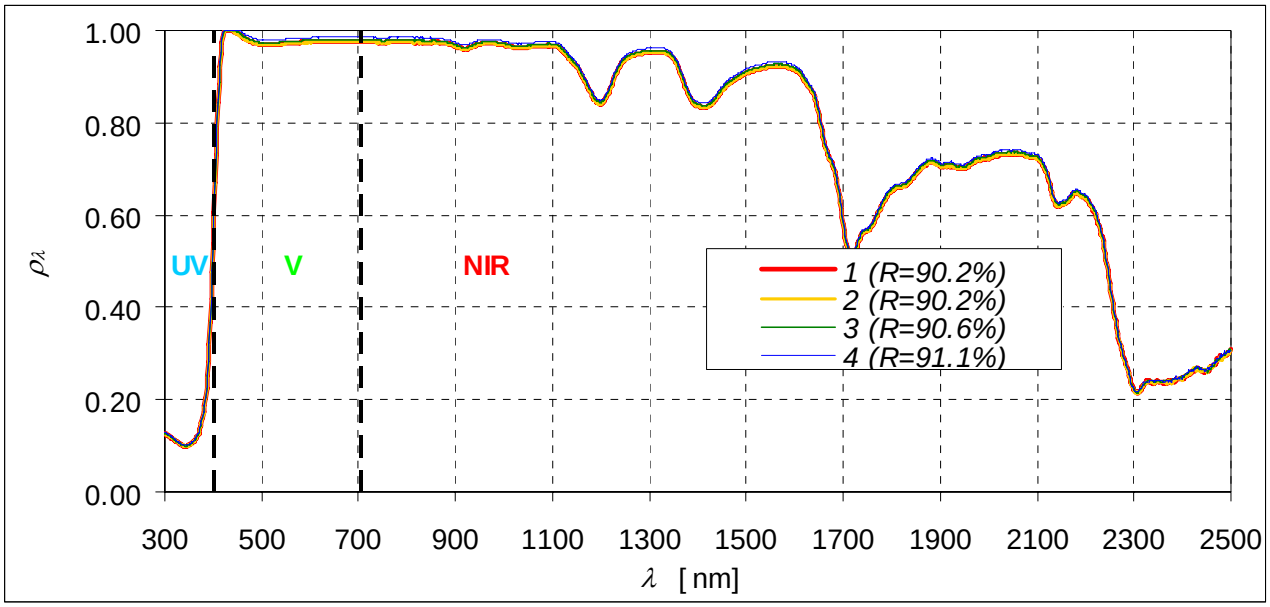


Figure 3.1. Spectral reflectivity.

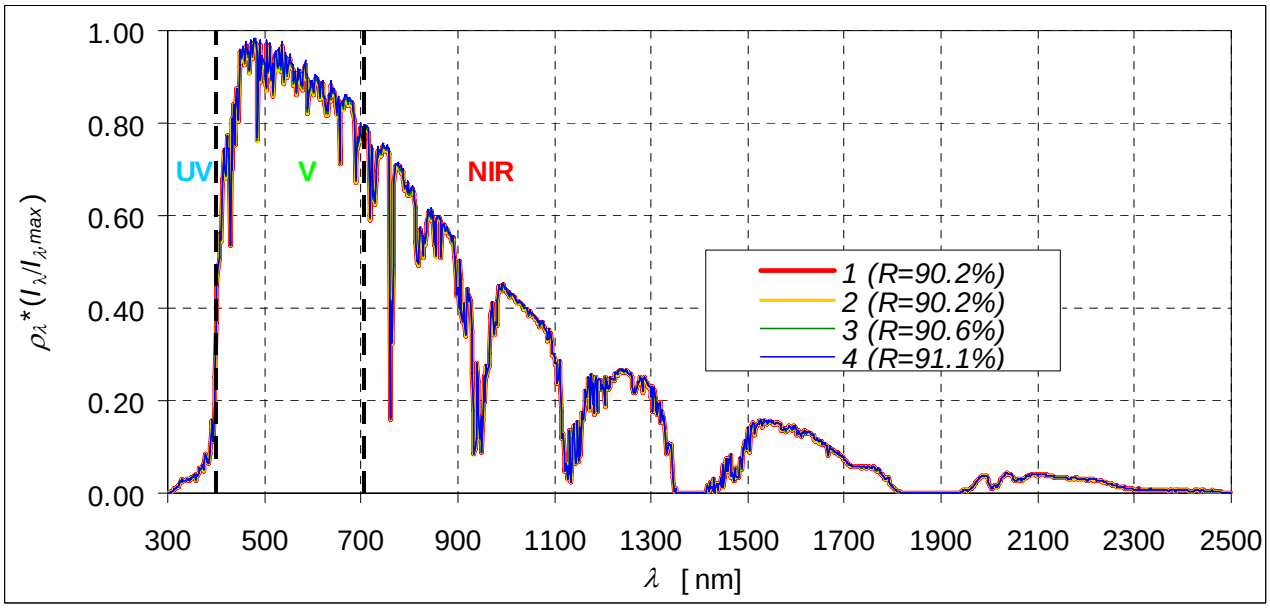


Figure 3.2. Spectral reflectivity multiplied by the normalized solar irradiance.

## 4. Measurements on weathered samples

Not performed (samples not yet delivered by the client company).