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Application News

Spectrophotometric Analysis No.A412B

Analysis of Adhesive Films for Glazings Conducted in Accordance with JIS A5759

In Application News No. A404, we introduced the plate glass analysis methods and its calculation methods in accordance with JIS R3106, "Testing Method on Transmittance, Reflectance and Emittance of Flat Glasses and Evaluation of Solar Heat Gain Coefficient". In this Application News, we introduce the methods for determining the visible transmittance, UV transmittance, shading coefficient, in addition to the coefficient of overall heat transmission for evaluation of the optical performance of adhesive films for glazings according to JIS A5759, "Adhesive Films for Glazings". As much of the information in JIS R3106 is also included in JIS A5759, please refer to Application News No. A404 as appropriate.

■ Visible Transmittance and UV Transmittance

Visible transmittance (τ_V) is determined using the weight averaging equation (1) which is obtained by multiplying the spectral transmittance $\tau(\lambda)$ in the wavelength range of 380 - 780 nm by the weight coefficient. UV transmittance (τ_{UV}) is determined using the weight averaging equation (2) based on the spectral transmittance in the wavelength range of 300 - 380 nm.

Spectral transmittance is obtained by conducting transmission measurement of 3 mm-thick plate glass with film applied to one side. The measurement is conducted using an UV-visible-near infrared spectrophotometer with an integrating sphere, with the incident light entering from the glass side.

$$\tau_V = \frac{\sum_\lambda \tau(\lambda)\cdot D\lambda\cdot V(\lambda)\cdot\Delta\lambda}{\sum_\lambda D\lambda\cdot V(\lambda)\cdot\Delta\lambda} \quad (1)$$

$$\tau_{UV} = \frac{\sum_\lambda \tau(\lambda)\cdot U\lambda\cdot\Delta\lambda}{\sum_\lambda U\lambda\cdot\Delta\lambda} \quad (2)$$

$D\lambda\cdot V(\lambda)\cdot\Delta\lambda$ and $U\lambda\cdot\Delta\lambda$ are weight coefficients specified in JIS A5759 for calculating the visible transmittance and UV transmittance, respectively. Note that these weight coefficients are different from that specified in JIS R3106.

■ Emittance for Solar Radiation and Coefficient of Overall Heat Transmission

The coefficient of overall heat transmission (U[W/m^{2}K] expresses the level of heat insulation efficiency, specifically, the amount of heat transmitted per unit time through 1 m^2 of glass surface when the difference of temperature on both sides of the film-coated glass is 1 ˚C. This coefficient of overall heat transmission is obtained using equation (3), which is obtained from the corrected emittance (ε), which is the normal emittance corrected by the coefficient specified in JIS A5759. Normal emittance is calculated using the reflectance of 30 specified wavelengths based on the spectral reflectance obtained from measurement conducted in the infrared region using an infrared spectrophotometer equipped with a specular reflectance measurement attachment. The method of measurement and calculation are the same as those specified in JIS R3106 (refer to "Normal Emittance" in Application News No. A404).

$$\frac{1}{U} = \frac{1}{4.9\varepsilon_e+16.3} + 0.003 + \frac{1}{5.4\varepsilon_i+4.1} \quad (3)$$

ε_e and ε_i are the corrected emittance values for the glass surface side (outside surface) and film surface side (inside surface), respectively.

■ Solar Transmittance and Reflectance, and Shading Coefficient

Solar transmittance (τ_e) and solar reflectance (ρ_e) are calculated using equations (4) and (5) from the spectral transmittance ($\tau(\lambda)$) and spectral reflectance ($\rho(\lambda)$), respectively, which are obtained from transmission measurement or reflection measurement using an UV-VIS-NIR spectrophotometer with an integrating sphere. A wavelength range of 300 - 2500 nm is used for both transmission measurement and reflection measurement, with light entering the glass surface side of the sample. $E\lambda\cdot\Delta\lambda$ is the weight coefficient specified in JIS A5759

$$\tau_e = \frac{\sum_\lambda \tau(\lambda)\cdot E\lambda\cdot\Delta\lambda}{\sum_\lambda E\lambda\cdot\Delta\lambda} \quad (4)$$

$$\rho_e = \frac{\sum_\lambda \rho(\lambda)\cdot E\lambda\cdot\Delta\lambda}{\sum_\lambda E\lambda\cdot\Delta\lambda} \quad (5)$$

This is basically the same as JIS R3106 except that the measurement wavelength ranges and weight coefficients are different.
The shading coefficient (S) is an index that expresses solar energy shielding performance. Only in the case of glazing, the sum of the portion of solar radiation transmitted through the glazing and the re-radiated portion of the temporarily absorbed energy by the incident and opposing surfaces of the glazing is a coefficient expressed as 1.
This shading coefficient is calculated from the solar transmittance (τ_e) and solar reflectance (ρ_e), and the corrected emittance (ε) using equations (6) and (7).

$$S = \frac{\tau_e+Ni\,(100-\tau_e-\rho_e)}{\tau_{eO}+0.35\,(100-\tau_{eO}-\rho_{eO})} \quad (6)$$

$$Ni = \frac{6.3\varepsilon_i+3.9}{(6.3\varepsilon_i+3.9)+(6.5\varepsilon_e+12.2)} \quad (7)$$

τ_{eo} and ρ_{eo} are solar transmittance and solar reflectance of plate glass.

■ Measurement of Adhesive Films for Glazings

The visible transmittance, UV transmittance, coefficient of overall heat transmission, and the shading coefficient were determined for 4 types of adhesive films applied to glazings. The analytical conditions are shown in Table 1 (UV-VIS-NIR spectrophotometer: UV-3600) and Table 2 (infrared spectrophotometer: IRAffinity-1). In addition, Fig. 1 shows the transmission spectra and reflection spectra (corrected using absolute reflectance of standard) in the UV-VIS-NIR region using the conditions of Table 1, and the reflection spectra in the infrared region using the conditions of Table 2. The measured samples consisted of plate glass used for the substrate and 4 types of applied glazings. Table 3 shows the visible transmittance, UV transmittance, coefficient of overall heat transmission and shading coefficient, in addition to solar transmittance, solar reflectance and corrected emittance for each sample. The visible transmittance, UV transmittance, solar transmittance and solar reflectance were calculated using solar transmittance measurement software, and the coefficient of overall heat transmission, shading coefficient and corrected emittance were calculated using commercially available spreadsheet software.

Table 1 Analytical Conditions of UV-VIS-NIR Spectrophotometer

Analytical instrument	: UV-3600, ISR-3100 (integrating sphere attachment)
Measurement wavelength range	: 300 nm - 2500 nm
Scan speed	: Medium
Sampling pitch	: 2.0 nm
Slit width	: (20) nm
Lamp switching wavelength	: 310 nm
Grating switching wavelength	: 720 nm
Detector switching wavelength	: 830 nm

Table 2 Analytical Conditions of FTIR

Analytical instrument	: IRAffinity-1, SRM-8000 (Specular reflectance measurement attachment)
Measurement wavelength range	: 5 µm - 25 µm (2000 - 400 cm^{-1})
Resolution	: 4 cm^{-1}
Accumulation	: 40
Apodization	: Happ-Genzel
Detector	: DLATGS

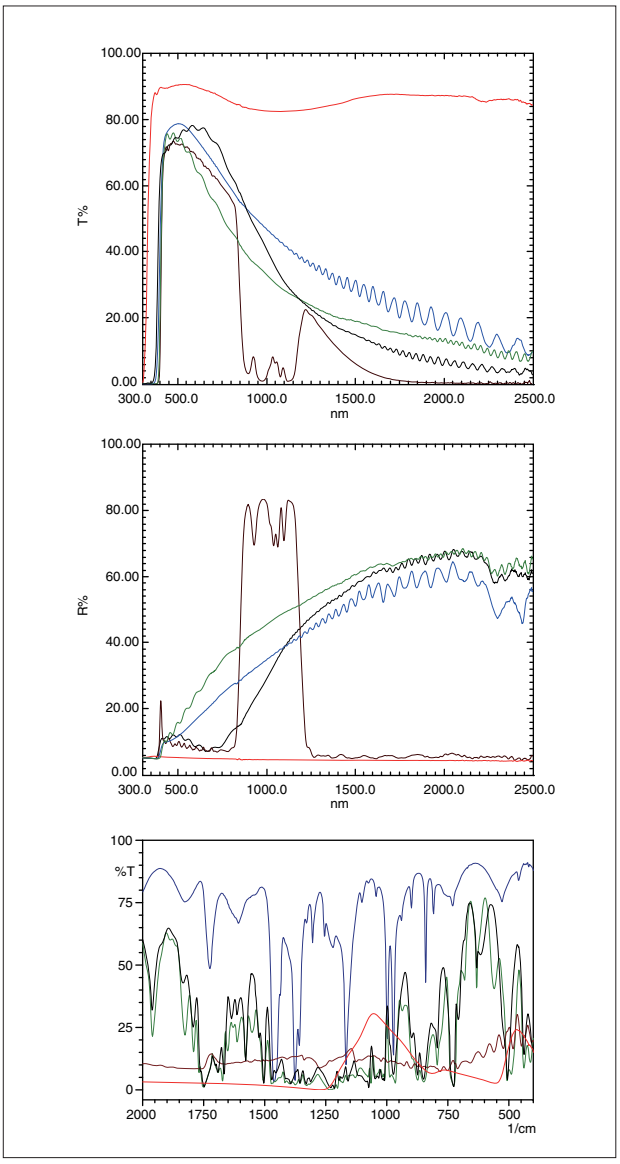

Fig.1 Transmission Spectra (upper) and Reflection Spectra (middle) in UV-VIS-NIR Region
Reflection Spectra (bottom) in Infrared Region
Blue: Film 1, Green: Film 2, Brown: Film 3, Black: Film 4, Red: Glass substrate

Table 3 Results for Adhesive Films for Glazings

Film	Visible Transmittance τ_V [%]	UV Transmittance τ_{UV} [%]	Solar Transmittance τ_e [%]	Solar Reflectance ρ_e [%]	Corrected Emittance ε	Shading Coefficient S	Coefficient of Overall Heat Transmission U [W/m^{2}K]
1	76.51	0.71	56.45	25.65	0.25	0.68	4.25
2	69.59	0.01	46.92	33.03	0.73	0.60	5.68
3	70.80	0.01	41.35	21.58	0.80	0.60	5.85
4	76.67	3.28	54.72	21.10	0.68	0.70	5.53
Glass Substrate	90.25	74.81	86.67	4.87	0.82		

NOTES:
✻This Application News has been produced and edited using information that was available when the data was acquired for each article. This Application News is subject to revision without prior notice.

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