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Application News

Spectrophotometric Analysis No.A404A

Glass Plate Analysis in Accordance with JIS R3106

The methods for determining visible light transmittance, or simply visible transmittance, visible reflectance, solar transmittance, solar reflectance and solar energy absorbance, and normal emittance and their respective methods of calculation are specified in JIS R3106 "Testing Method on Transmittance, Reflectance and Emittance of Flat Glasses and Evaluation of Solar Gain Coefficient". Of these indices, which express the characteristics of plate glass, solar transmittance and its determination was introduced in Application News A396. The remaining plate glass indices are introduced here.

■ Visible Transmittance and Reflectance

Visible transmittance (τ v) and visible reflectance (ρ v) are calculated by equations (1) and (2) below, using the spectral transmittance ($\tau(\lambda)$) and spectral reflectance ($\rho(\lambda)$) values, respectively, measured in the wavelength range of 380 – 780 nm with an ultraviolet-visible-near infrared spectrophotometer equipped with an integrating sphere. In the equations, $D\lambda \cdot V\lambda$ is the weight coefficient specified in JIS R3106 for calculating visible transmittance and visible reflectance.

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

$$\rho v = \frac{\sum_{\lambda} D\lambda \cdot V\lambda \cdot \rho(\lambda)}{\sum_{\lambda} D\lambda \cdot V\lambda} \quad (2)$$

Spectral transmittance ($\tau(\lambda)$) is obtained by conducting transmittance measurement of incident light penetrating the plate glass at a normal angle, using air as the standard sample (reference sample). Spectral reflectance ($\rho(\lambda)$) is obtained by conducting reflectance measurement using a specular reflector of specified absolute reflectivity as the standard sample. Incident light is irradiated into the sample at an angle that does not exceed 15°. To exclude the influence of reflected light from the back, an optical trap such as black tape is affixed to the rear surface of the glass.

■ Normal Emittance

To determine the normal emissivity, specular reflectance ($\rho n(\lambda)$) measurement is conducted in the infrared region using an infrared spectrophotometer equipped with a specular reflectance attachment. Reflectance ρn is calculated from equation (7) using the reflectance of 30 specified wavelengths among the measured values. Then, normal emittance (εn) is obtained from equation (8).

■ Solar Transmittance, Solar Reflectance and Evaluation of Solar Gain Coefficient (SHGC)

Solar transmittance (τe) and solar reflectance (ρe) are calculated with equations (3) and (4) below, using the spectral transmittance ($\tau(\lambda)$) and spectral reflectance ($\rho(\lambda)$) values, respectively, measured using an ultraviolet-visible-near infrared spectrophotometer equipped with an integrating sphere. In the equations, $E\lambda \cdot \Delta\lambda$ is the weight coefficient indicating the standard spectrum distribution of solar energy as specified in JIS R3106.

$$\tau e = \frac{\sum_{\lambda} E\lambda \cdot \Delta\lambda \cdot \tau(\lambda)}{\sum_{\lambda} E\lambda \cdot \Delta\lambda} \quad (3)$$

$$\rho e = \frac{\sum_{\lambda} E\lambda \cdot \Delta\lambda \cdot \rho(\lambda)}{\sum_{\lambda} E\lambda \cdot \Delta\lambda} \quad (4)$$

The solar gain coefficient (αe) is calculated from the spectral absorption ($\alpha(\lambda)$) expressed by equation (5), and by equation (6).

$$\alpha(\lambda) = 1 - \tau(\lambda) - \rho(\lambda) \quad (5)$$

$$\alpha e = \frac{\sum_{\lambda} E\lambda \cdot \Delta\lambda \cdot \alpha(\lambda)}{\sum_{\lambda} E\lambda \cdot \Delta\lambda} \quad (6)$$

The spectral transmittance and spectral reflectance measurements are the same as for the visible transmittance and visible reflectance, but the measurement wavelength range is 300 - 2100 nm. However, the weight coefficient for 2150 - 2500 nm is also indicated in JIS R3106, and calculation based on measurement in the wavelength range of 300 - 2500 nm is also possible.

$$\rho n = \frac{1}{30} \sum_{i=1}^{30} \rho n(\lambda i) \quad (7)$$

$$\varepsilon n = 1 - \rho n \quad (8)$$

Measurement of spectrum reflectance is conducted in the range of at least 5 - 25 μm (wavenumber 2,000 to 400 cm^{-1}) at a resolution of 4 cm^{-1} or less within the ambient temperature heat emittance wavelength region of 5 - 50 μm (wavenumber 2,000 to 200 cm^{-1}). Incident light is irradiated onto the sample at an angle not greater than 15°. For comparison, an aluminum-coated mirror with certified absolute reflectance (float glass with vacuum-deposited aluminum film) is used. If a certified surface-coated mirror is not available, the standard reflectance value specified in JIS R3106 is used. If the measurement wavelength of 50 μm (200 cm^{-1}) cannot be attained, the spectral reflectance value at the measured upper limit wavelength is used as the value for longer wavelengths.

■ Measurement of Opaque Glass

Measurements were conducted on 4 types of commercial plate glass to determine their respective visible transmittance, visible reflectance, solar transmittance, solar reflectance, solar absorbance, and normal emittance values. The measurement conditions that were used are shown in Table 1 (UV-VIS-NIR spectrophotometer) and Table 2 (FTIR spectrophotometer). In addition, the transmission spectra and reflection spectra in the UV-VIS-NIR region (corrected using absolute reflectance of standard sample) obtained using the conditions of Table 1, and the reflection spectra in the infrared region obtained using the conditions of Table 2 are shown in Fig. 1. The specimens consisted of 1 type of transparent glass and 3 types of opaque glass. It is clear from the data of Fig. 1 that large differences in both transmittance and reflectance exist in the UV-VIS-NIR region, but the reflectance values in the infrared region were about the same.

Table 3 shows the values calculated for visible transmittance, visible reflectance, solar transmittance, solar reflectance, solar absorbance, and normal emittance for each sample.

Calculation of the visible transmittance, visible reflectance, solar transmittance, and solar reflectance was conducted using solar transmittance measurement software, and calculation of the solar absorbance and normal emittance was conducted using a commercial spreadsheet software application.

Table 1 Analytical Conditions of UV-VIS-NIR Spectrophotometer

Analytical instrument	: UV-3600, ISR-3100 (Integrating Sphere Attachment)
Measurement wavelength range	: 300 nm—2100 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

Table 3 Results for Opaque Glass Specimens

	Visible		Solar			Normal
	Transmittance	Reflectance	Transmittance	Reflectance	Absorbance	Emittance
Sample	τv [%]	ρv [%]	τe [%]	ρe [%]	αe [%]	εn [%]
Transparent glass	91.25	4.41	89.52	5.08	5.40	87.39
Opaque glass 1	63.13	17.09	63.01	11.90	25.10	87.35
Opaque glass 2	53.79	13.88	37.86	8.57	53.57	87.44
Opaque glass 3	34.82	8.07	40.28	6.96	52.77	87.45

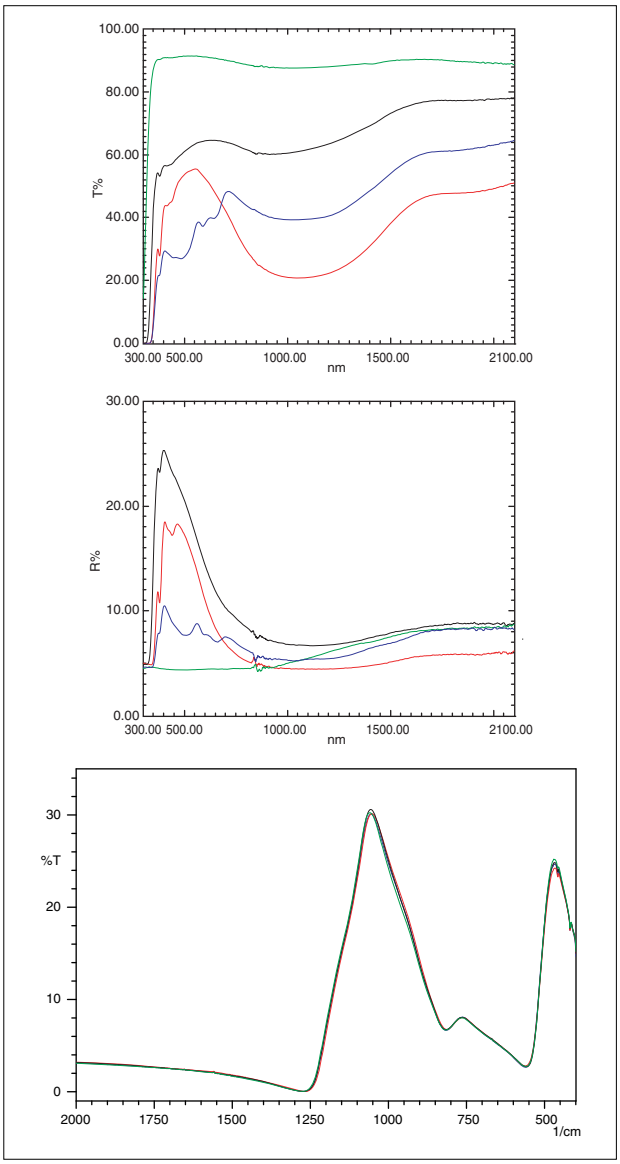

Fig. 1 Transmission Spectra (upper) and Reflection Spectra (middle) in UV-VIS-NIR RegionReflection Spectra (bottom) in Infrared Region
Green: Transparent glass, Black: Opaque glass 1, Red: Opaque glass 2, Green: Opaque glass 3

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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