SAE International

SURFACE VEHICLE STANDARD

SAE J1796

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Spectral Transmission Test

This document is similar to the ISO Draft Standard and “Solar Transmittance Test” that is under discussion in ISO/TC22/SC11.

1. Scope

The scope of this SAE performance standard is to define the test method by which the direct solar and visible transmission of safety glazing materials for road vehicles shall be measured. Adherence to this performance standard will facilitate writing, use and referencing of reports by government, industry and other organizations.

1.1 Purpose

The purpose of this performance standard is to determine the direct solar and visible and color transmittance of safety glazing materials for road vehicles.

1.2 Application

The performance standard applies to monolithic or laminated, clear or tinted samples of safety glazing materials. Essentially flat sections of glazing parts may be used in this test as well as flat samples of the same materials.

1.3 Rationale

This document is being written to standardize calculations and communications involving spectral transmission data from safety-glazing materials for road vehicles. This revised document now conforms with the computational convention "A" in ISO 13837.

2. References

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein.

2.1.1 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO 13837—Road vehicles—Safety glazing materials—Method for the determination of solar transmittance *[ISO/TC22 N 2455 10FEV.1997]*
ISO 9845-1:1992(E)—Solar Energy—Reference solar spectral irradiance at the ground at different receiving conditions—Part 1: Direct normal and hemispherical solar irradiance for air mass 1.5—Table 1 – Spectral solar irradiance [column 5]

2.1.2 CIE Publications

Available from CIE Central Bureau, Kegelgasse 27, A-1030 Vienna, AUSTRIA

CIE Publication No. 85—Technical Report—Solar Spectral Irradiance
CIE Publication No. 15.2—Colorimetry 2nd ed.

2.1.3 ASTM Publications

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 308-96—Standard Test Method for Computing the Colors of Objects by Using the CIE System
ASTM E 380-93—Practice for the use of the International System of Units (SI) (the Modernized Metric System)

3. Definitions

3.1 Standardize

To adjust an instrument output to correspond to a previously established calibration using one or more homogeneous specimens or reference materials.

3.2 Transmittance

The ratio of transmitted flux to incident flux, under specified geometric and spectral conditions.

3.3 Air Mass (ratio)

The ratio of the mass of atmosphere in the actual observer-sun path to the mass that would exist if the observer were at sea level, at standard barometric pressure, and the sun were directly overhead.

3.4 Solar UV Transmittance T_{UV}

The transmittance weighted, interval by interval, derived from ISO 9845, Table 1, column 5, E_{λ_i}. *(air mass = 1.5 global)*[1] distribution from 300 through 400 nanometers (nm) at 5 nm intervals [Table 1].

3.5 Solar Direct Transmittance T_{DS}

The transmittance weighted, interval by interval, derived from modified ISO 9845, Table , column 5, E_{λ_i} *(air mass = 1.5 global)*[2] distribution from 300 through 2500 nanometers (nm) at 5, 10, 50 nm intervals [Table 2].

3.6 Visible Luminous Transmittance (LT_A)

Illuminant **A** spectral power distribution [2856 °K correlated color temperature] multiplied by the spectral luminous efficiency function for photopic vision [V(λ)]. The transmittance weighted, interval by interval, according to ASTM 308 (90), 7.1.1 and 7.2.1 (Abridged Calculation Procedure) and Table 5.1, column (y). This is nearly equivalent to *CIE Publication No. 15.2, Table 1.1* **A** *times Table 2.1* $\bar{y}(\lambda)$ distribution from 380 through 780 nanometers (nm) at 10 nm intervals.

NOTE—$V(\lambda) = \bar{y}(\lambda)$ [CIE Publication 15.2, p. 20, Note 3]. See 4.2.3.4.

3.7 Color Transmittance (X,Y,Z)

Illuminant D65 spectral power distribution [6500 °K correlated color temperature] multiplied by the CIE 1964 supplementary standard colorimetric observer. The transmittance weighted, interval by interval, according to ASTM E 308 (96), Table 5.19. This is equivalent to *CIE Publication No. 15.2, Table 1.1* $\mathbf{D_{65}}$ *times Table 2.2* $\bar{x}_{10}(\lambda)$, $\bar{y}_{10}(\lambda)$, $\bar{z}_{10}(\lambda)$ distribution from 380 through 780 nanometers (nm) at 10 nm intervals. See 4.2.3.5.

4. Test Method

4.1 Apparatus—Measuring Instrument

This method requires spectral transmittance data to be obtained from samples of glazing materials using a scanning spectrophotometer. This instrument, preferably equipped with an integrating sphere, must be capable of measuring transmittance over that part of the electromagnetic spectrum in which the sun's energy is transmitted to the earth's surface. Wavelength range: required = 300 through 2300 nm, preferred = 300 through 2500 nm.

[1] Modified ISO 9845-1 Table 1, column 5 is equivalent to ISO 13837, Table 1, E_{λ_i}.
[2] Modified ISO 9845-1 Table 1, column 5 is equivalent to ISO 13837, Table 2, E_{λ_i}.

4.2 Procedure

4.2.1 SAMPLE PREPARATION

Cut, if necessary, and clean the flattest area of curved test specimens with distilled water and reagent grade methanol or use an alternate procedure appropriate to the material if necessary. Cut and clean flat samples similarly.

4.2.2 MEASUREMENT

Standardize the spectrophotometer according to the manufacturer's instructions. Place a clean sample normal to the measuring beam in the transmittance sample position. Note its film side and curvature orientation if applicable. Record the sample spectral data according to the instrument manufacturer's recommendation.

4.2.3 CALCULATION

Compute direct solar transmittance by integration using the solar weight data in Tables 1 and 2.

4.2.3.1 Transmission (T) for each solar range (λ_1 to λ_n) is determined by Equation 1 and Equation 2.

$$\%T_{UV}(400) = \Sigma_{300}^{400} \%T_{\lambda} \times E'_{\lambda}(\eta) \quad \{\text{Table 1}\} \qquad \text{(Eq. 1)}$$

$$\%T_{DS}(1.5) = \Sigma_{300}^{2500} \%T_{\lambda} \times E'_{\lambda}(\eta) \quad \{\text{Table 2}\} \qquad \text{(Eq. 2)}$$

where:

$E'_{\lambda}(\eta)$ is the normalized trapezoidal solar energy in wavelength interval $[\Delta\lambda\eta]$.

4.2.3.2 Measure transmittance at intervals of 5 nm from 300 nm to 400 nm, 10 nm from 400 nm to 800 nm, and 50 nm from 800 nm to 2500 nm. Transmittance must be measured to at least 2300 nm. If it is not possible to measure transmittance to 2500 nm, the last value must be multiplied by the remaining $[E'\lambda \times \Delta\lambda]$ weight values.

4.2.3.3 This standard defines the determination of the direct solar transmittance of safety glazing materials.

4.2.3.4 Luminous transmittance (LT_A) for the visible range (380 nm to 780 nm) is determined by the following function:

$$\%LT_A = \sum_{380}^{780} \%T_{\lambda} \times V(\lambda) \times E_{\lambda}(A) \times \Delta\lambda \qquad \text{(Eq. 3)}$$

Note this is equivalent to summing the product of the "Y" column of Table 5.1 in ASTM E 308-96 by $\%T_{\lambda}$ of the specimen.

4.2.3.5 Transmission color for the visible range is determined by the following functions:

$$\%T_X = \sum_{380}^{780} \%T_\lambda \times X_{10}(\lambda) \times E_\lambda(D_{65}) \times \Delta\lambda$$

$$\%T_Y = \sum_{380}^{780} \%T_\lambda \times Y_{10}(\lambda) \times E_\lambda(D_{65}) \times \Delta\lambda \qquad \text{(Eqs. 4)}$$

$$\%T_Z = \sum_{380}^{780} \%T_\lambda \times Z_{10}(\lambda) \times E_\lambda(D_{65}) \times \Delta\lambda$$

Note these equations are equivalent to summing the products of the "X," "Y," and "Z" columns of Table 5.19 in ASTM E 308-96 by $\%T_\lambda$ of the specimen. See 3.7.

Calculated values from Equations 4, abbreviated to X, Y, Z are inserted into the following CIELAB (L*, a*, b*) equations:

$$L^* = 116 \times \left(\frac{Y}{Y_n}\right)^{\frac{1}{3}} - 16$$

$$a^* = 500 \times \left[\left(\frac{X}{X_n}\right)^{\frac{1}{3}} - \left(\frac{Y}{Y_n}\right)^{\frac{1}{3}}\right] \qquad \text{(Eqs. 5)}$$

$$b^* = 200 \times \left[\left(\frac{Y}{Y_n}\right)^{\frac{1}{3}} - \left(\frac{Z}{Z_n}\right)^{\frac{1}{3}}\right]$$

where:

$X_n = 94.811$
$Y_n = 100.000$
$Z_n = 107.304$

{sums in Table 5.19 in ASTM E 308-96}.

4.2.4 EXPRESSION OF RESULTS

Record thickness, type, construction, and curvature orientation, if applicable, of the specimen, the instrument used, and the specimen's direct solar and visible transmittance rounded to 0.1%. Report color transmittance rounded to 0.1% L* and 0.01 a* and b* in accordance with ASTM E 380-93 rounding convention.

TABLE 1—SOLAR UV TRANSMITTANCE

(λ nm)	E'λ(η)
300	0.000000
305	0.001045
310	0.004634
315	0.011800
320	0.019807
325	0.027019
330	0.043271
335	0.042703
340	0.047644
345	0.048041
350	0.052948
355	0.054947
360	0.056946
365	0.064930
370	0.072925
375	0.075901
380	0.077991
385	0.075890
390	0.073777
395	0.092335
400	0.055446

$$\%T_{UV}(400) = \Sigma_{300}^{400} \%T_{\lambda} \times E'_{\lambda}(\eta)$$

Normalized relative spectral distribution of air mass 1.5 global solar radiation, $E'_{\lambda}(\eta)$, multiplied by the trapezoidal wavelength interval, $\Delta\lambda$. (Modified wavelength intervals in ISO 9845-1; 1992(E), Table 1, column 5 and equivalent to ISO 13837, Table 1.)