INTERNATIONAL STANDARD

ISO 13837

Second edition
2021-09

Road vehicles — Safety glazing materials — Method for the determination of solar transmittance

Véhicules routiers — Vitrages de sécurité — Méthode de détermination du facteur de transmission du rayonnement solaire

Reference number
ISO 13837:2021(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 35, *Lighting and visibility*.

This second edition cancels and replaces the first edition (ISO 13837:2008), which has been technically revised.

The main changes compared to the previous edition are as follows:

— deletion of definitions of convention “A” and convention “B”;

— deletion of all texts and tables corresponding to air mass 1,0 global;

— revision of 3.1;

— addition of some symbol definitions for variables and parameters;

— addition of calculation methods for luminous transmittance [T_L], solar direct reflectance [R_e], solar direct absorbance [a_e] and colorimetry;

— revision of calculation method for solar UV transmittance $\left[T_{UV(380)}\right]$ to calculate with air mass 1,5 global;

— addition of a new Table 1 for calculation of luminous transmittance [T_L], a new Table 2 for calculation of solar UV transmittance [$T_{UV(380)}$], and a new Table 5 for calculation of colorimetry;

— revision of Table 3 (former Table 1) for calculation of solar UV transmittance [$T_{UV(400)}$], Table 4 (former Table 2) for calculation of solar direct transmittance [T_e], solar direct reflectance [R_e], and Table A.1 for explanation of the derivation process;

— revision of Annex A to list the source of values in the new solar weight tables and give out the derivation process of Table 3 as an example;

- deletion of Figure A.1 and Figure A.2;
- moving of texts of Annex B to 5.3.7 and revision of text structure;
- revision of Bibliography;
- editorial update.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

A review of existing standards and industry specifications and procedures reveals a lack of agreement with respect to the basis for defining and measuring the ultraviolet (UV), visible (VIS), infrared (IR) transmittance and colorimetry (L^*, a^*, b^*) properties of glazing materials. To avoid the continued preparation and promulgation of conflicting standards by individual entities, there is an interest in the automotive and glazing industries to harmonize on a worldwide basis the test procedures and protocols used to assess the solar transmittance properties of glazing materials.

Road vehicles — Safety glazing materials — Method for the determination of solar transmittance

1 Scope

This document specifies test methods to determine the luminous, the direct and total solar transmittance, and the colorimetry of safety glazing materials for road vehicles.

This document applies to monolithic or laminated, clear or tinted samples of safety glazing materials. Essentially flat sections of glazing parts can be used in this test, as well as flat samples of the same materials.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/CIE 11664-4:2019, *Colorimetry — Part 4: CIE 1976 L*a*b* colour space*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
air mass
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

3.2 Symbols

T_L	luminous transmittance for CIE standard illuminant A with 2 degree view through a glazing
T_λ	transmittance through a glazing at wavelength λ within a specified $\Delta\lambda$
W_λ	normalized luminous transmittance weighting coefficient
$T_{UV(380)}$	ultraviolet (UV) direct solar energy transmitted through the glazing at a specified upper limit value (380 nm)
$E'_{\lambda(n)}$	normalized relative spectral distribution of global solar radiation
$T_{UV(400)}$	ultraviolet (UV) direct solar energy transmitted through the glazing at a specified upper limit value (400 nm)

T_e	direct solar energy (e) transmitted through the glazing
R_e	direct solar energy (e) reflected by the glazing
R_λ	external reflectance (R) of a glazing at wavelength λ within a specified $\Delta\lambda$
a_e	direct solar energy (e) absorbed by the glazing
T_{TS}	total solar energy ($T_e + q_i$) transmitted through the glazing
q_i	secondary heat flux through the glazing
h_e	heat flux of the safety glazing material towards the outside
h_i	heat flux of the safety glazing material towards the inside
v	wind velocity
ε_i	corrected emissivity
X_{10}, Y_{10}, Z_{10}	tristimulus values calculated using the CIE 1964 standard colorimetric observer under CIE standard illuminant D65 spectral power distribution
$W_{10,X(\lambda)}$, $W_{10,Y(\lambda)}$, $W_{10,Z(\lambda)}$	pre-calculated weighting functions for tristimulus integration using the CIE 1964 standard colorimetric observer
X_n, Y_n, Z_n	tristimulus values of a specific white colour stimulus calculated using the colour-matching functions of the CIE 1931 standard colorimetric system
L^*, a^*, b^*	coordinates of the CIE 1976 $L^*a^*b^*$ colour space; L^*, CIELAB lightness; a^*, b^*, CIELAB coordinates
λ	wavelength, in nm
S_λ	relative spectral distribution of global solar radiation
$\Delta\lambda$	uniform λ interval
E_λ	solar energy within a $\Delta\lambda$
E'_λ	E_λ in trapezoidal form ($E_1/2$, E_2 … E_{n-1}, $E_n/2$)

4 Apparatus

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, shall be capable of measuring transmittance over that part of the electromagnetic spectrum in which the solar energy is transmitted to the earth's surface.

5 Procedure

5.1 Sample preparation

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

5.2 Measurement

Standardize the spectrophotometer in accordance with the manufacturer's instructions. Measure transmittance/reflectance of cleaned sample and record the sample spectral data in accordance with the instrument manufacturer's recommendation. Note its film/coating side and curvature orientation, if applicable.

5.3 Calculation method

5.3.1 Luminous transmittance [T_L]

The luminous transmittance T_L shall be calculated using the weight data of visible radiation of CIE standard illuminant A in Table 1 and Formula (1):

$$T_L = \sum_{380}^{780} T_\lambda \times W_\lambda \tag{1}$$

5.3.2 Solar UV transmittance [$T_{UV(380)}$]

The solar UV transmittance $T_{UV(380)}$ shall be calculated using the solar weight data in Table 2 and Formula (2):

$$T_{UV(380)} = \sum_{300}^{380} T_\lambda \times E'_{\lambda(n)} \tag{2}$$

5.3.3 Solar UV transmittance [$T_{UV(400)}$]

The solar UV transmittance $T_{UV(400)}$ shall be calculated using the solar weight data in Table 3 and Formula (3):

$$T_{UV(400)} = \sum_{300}^{400} T_\lambda \times E'_{\lambda(n)} \tag{3}$$

NOTE Annex A gives out an example of the derivation process for Table 3.

5.3.4 Solar direct transmittance [T_e]

The solar direct transmittance T_e shall be calculated using the solar weight data in Table 4 and Formula (4):

$$T_e = \sum_{300}^{2\,500} T_\lambda \times E'_{\lambda(n)} \tag{4}$$

5.3.5 Solar direct reflectance [R_e]

The solar direct reflectance R_e shall be calculated using the solar weight data in Table 4 and Formula (5):

$$R_e = \sum_{300}^{2\,500} R_\lambda \times E'_{\lambda(n)} \tag{5}$$

5.3.6 Solar direct absorbance [a_e]

The solar direct absorbance a_e shall be calculated using Formula (6):

$$a_e = 100 - T_e - R_e \quad (6)$$

where 100 is expressed in percentage (%).

5.3.7 Total solar transmittance [T_{TS}]

5.3.7.1 The total solar transmittance T_{TS} shall be calculated by Formula (7):

$$T_{TS} = T_e + q_i \quad (7)$$

5.3.7.2 The secondary heat flux through the glazing q_i of a single glazing shall be calculated by Formula (8):

$$q_i = a_e \times \frac{h_i}{h_i + h_e} \quad (8)$$

5.3.7.3 h_e and h_i mainly depend on the position of the safety glazing material, wind velocity, inside and outside temperatures, as well as on the temperature of the two external glazing material surfaces. As the purpose of this document is to provide basic information on the performance of safety glazing materials, conventional conditions have been stated for simplicity, as specified below:

a) The position of the safety glazing material is vertical;

b) Outside surface:

   1) wind velocities:

      — v_1 = approximately 4 m/s for vehicles at rest;

      — v_2 = 14 m/s for vehicles at 50 km/h;

      — v_3 = 28 m/s for vehicles at 100 km/h;

      — v_4 = 42 m/s for vehicles at 150 km/h.

   2) Hemispherical emissivity = 0,837;

   3) Radiative heat flux was not considered.

c) Inside surface:

   1) natural convection;

   2) emissivity is an optional consideration.

5.3.7.4 Under above conventional, average conditions, standard values of h_{e1} to h_{e4} are obtained as follows:

— h_{e1} = 21 W/(m^2·K) at v_1;

— h_{e2} = 56 W/(m^2·K) at v_2;

— h_{e3} = 97 W/(m^2·K) at v_3;

— h_{e4} = 133 W/(m²·K) at v_4;

where

$$\text{for } v < 5 \text{ m/s}, \; h_e = 5{,}6 + 3{,}9\, v \tag{9}$$

$$\text{for } v \geq 5 \text{ m/s}, \; h_e = 7{,}2\, v^{0{,}78} \tag{10}$$

NOTE For Formulae (9) and (10), see Reference [11].

5.3.7.5 For h_i, expressed in W/(m²·K), shall be calculated by Formula (11):

$$h_i = 3{,}6 + \frac{4{,}4\varepsilon_i}{0{,}837} \tag{11}$$

NOTE For ordinary glass, $\varepsilon_i = 0{,}837$ and h_i = 8 W/(m²·K).

5.3.7.6 The corrected emissivity ε_i is defined and measured in accordance with ISO 10292. If other heat flux is used to calculate the secondary heat flux in order to meet special boundary conditions, this shall be reported.

NOTE Values lower than 0,837 for ε_i (due to surface coatings with higher reflection in the far infrared) are only considered if water condensation on the coated surface can be excluded.

5.3.7.7 For multiple safety glazing materials, e.g. double glazing, and for vehicles at rest and in motion, the definitions and formulae used in ISO 9050 can be applied, if necessary, to calculate the total solar transmittance T_{TS}.

5.3.8 Colorimetry

5.3.8.1 Tristimulus value X_{10}, Y_{10}, Z_{10}

Calculate tristimulus value (X_{10}, Y_{10}, Z_{10}) by CIE standard illuminant D65 tristimulus weighting functions ($W_{10,X(\lambda)}$), ($W_{10,Y(\lambda)}$) and ($W_{10,Z(\lambda)}$) in Table 5. Tristimulus value (X_{10}, Y_{10}, Z_{10}) for the visible range is determined by Formulae (12), (13) and (14):

$$X_{10} = \sum_{380}^{780} T_\lambda \times W_{10,X(\lambda)} \tag{12}$$

$$Y_{10} = \sum_{380}^{780} T_\lambda \times W_{10,Y(\lambda)} \tag{13}$$

$$Z_{10} = \sum_{380}^{780} T_\lambda \times W_{10,Z(\lambda)} \tag{14}$$

5.3.8.2 CIE 1976 L^*, a^*, b^* colour space

Calculate L^*, a^*, b^* values in accordance with ISO/CIE 11664-4:2019, 5.1 using (X_{10}, Y_{10}, Z_{10}) calculated above and white point data in Table 5 as (X_n, Y_n, Z_n).