Determination of direct solar transmission according to various standards

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Abstract

At present time for the determination of glass optical properties towards for solar radiation some standards are applied. Determination methods in these standards are identical, but it cannot be said the same about their calculation database. Therefore a discrepancy between calculation results by different standards is possible. Solar direct transmittance calculations for some types of glass by means of different standards were made by authors and the extent of result difference was estimated according to their optical properties.

Introduction

One of the building glass major characteristics besides the ability to transmit visible light is its ability to transmit solar radiation in UV-VIS-NIR-range (so called solar direct transmittance). Solar direct transmittance data are extensively used in glazing design. International standard methods for the determination these data are established. These methods include material spectrophotometric characteristics measurements and a calculation on basis of these measurements data and normalized relative spectral distribution of global solar irradiation. Spectral distribution of the global solar irradiation kind is a parameter conditional on multitude factors connected with geographical area location: a solar zenith angle, surfaces tilt at the latitude angle, that specify an air mass (AM)* and atmospheric parameters, such as temperature, pressure, aerosol density, air density, precipitable water vapour, ozone content. The standards provide normalized relative spectral distribution of global solar radiation for standard conditions established by CIE [1, 2]. But these conditions are not always coincided. For example: the last ISO-9050 variant (2003) gives spectral distribution of global solar radiation for AM = 1,5, but EN-410 – for AM = 1. Earlier version ISO-9050 (1990) suggested two calculation variants: by CIE [1] for AM = 1 and by Moon [3] for AM = 2. Furthermore the differences are in the wave range (300-2500nm or 350-2100nm) and in wave interval and in value numbers of wavelengths for which calculation data are given. In “old” ISO there are 20 calculation points (by CIE) and 36 points (by Moon), in “new” ISO we see 95 points, in EN-410 – 56. More detailed information about conditions and appropriate spectral distribution of global solar radiation are contained in [4-6]. Thereby discrepancies are possible when different standards used. Although ISO 9050 is mainly used at present, it is reasonable to identify possible differences between data obtained with the help of different standards. Because even very small differences can result in setting the question – is this glass product correspond to announced parameters or not and give rise to the discussion between suppliers and users. Also, similar differences may appear in solar direct reflectance calculations and in solar direct absorption calculations accordingly and lead up to differences in heat and optical calculations.

Solar direct transmittance calculations

For estimation of possible differences we carry out the solar direct transmittance calculations for some glass specimens using the following standards: I – ISO-9050 1990 according to CIE (300-2500 nm range, 20 calculation points, AM=1)**; II – ISO-9050 1990 according to Moon (350-2100 nm range, 36 calculation points, AM=2), III – EN-410 (300-2500 nm range, 56 calculation points, AM=1), IV – ISO-9050 2003 (300-2500 nm range, 95 points, AM=1,5), V - ISO-9050 2003, but with calculation points quantity (20) and their values similar to ISO-9050 1990 (CIE). Last variant has a purpose to check possibility of the simplified calculation with using 20 points instead of 95, because calculation with using 95 points is very laborious process for those who have no up-to-date equipment permitting to automate the measurement. There is no secret that there are quite a number interested in simplified variant so far. For conversion to 20 points we made according re-calculation and normalization of relative spectral distribution of global solar radiation values. In Figure 1 you see relative spectral distribution of global solar radiation given in different standards.

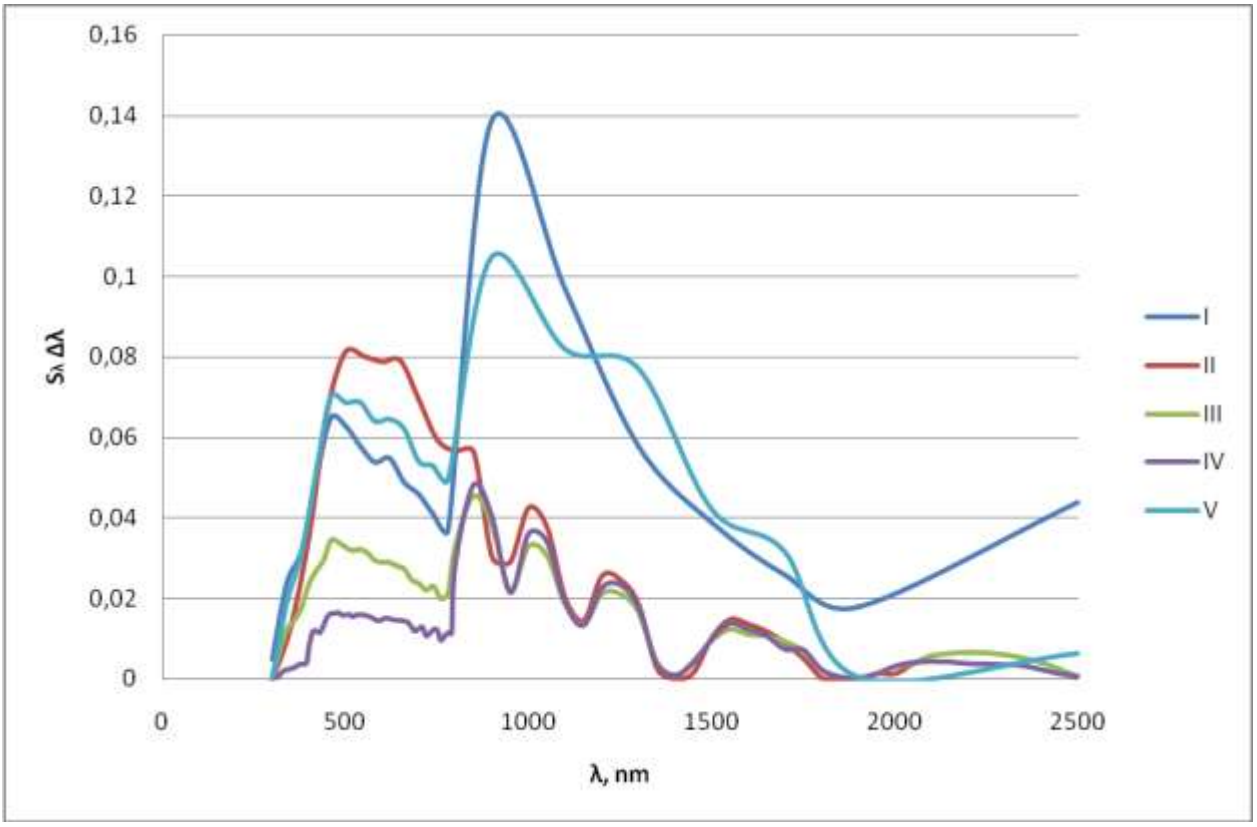

Figure 1 Normalized relative spectral distribution of global solar radiation curves according different standards: I – ISO-9050 (1990, CIE); II – ISO-9050 (1990, Moon); III – EN-410; IV – ISO-9050 (2003); V - ISO-9050 (2003, simplified variant)

Calculations were made for various glass types having different spectral characteristics: clear glass, colored glass with transmittance mainly blue or red spectral band and coated glass also. Figure 2 represents the transmission spectra of the analyzed glass specimens. The spectra were recorded using spectrophotometers SF-26 (300-1200 nm) and IKS-14A (750-2500 nm).

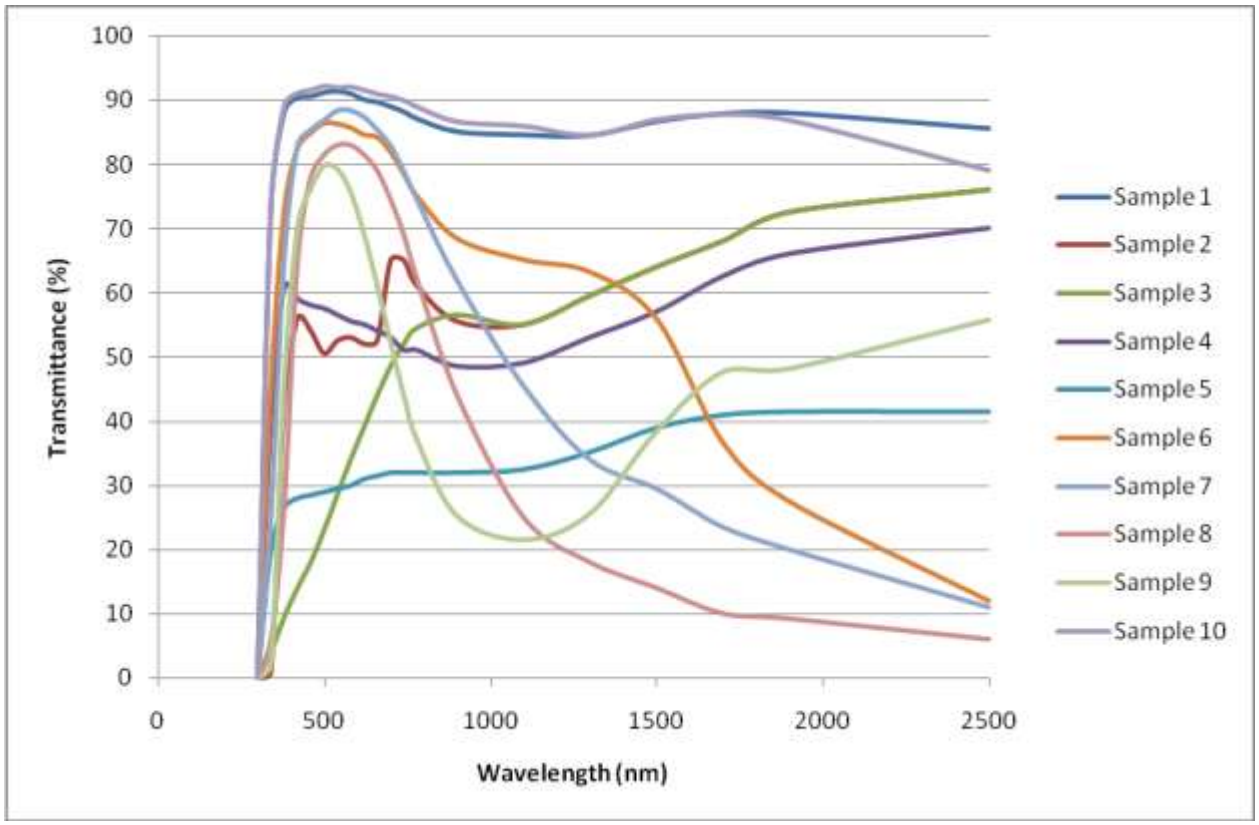

Figure 2 Transmission spectra characters of the analyzed glass specimens

Table 1 shows the results of the solar direct transmittance calculations for the analyzed glass specimens

Glass specimen number	The solar direct transmittance by standards				
	I – ISO-9050 1990, AM=1 20 (.), CIE	II – ISO-9050 1990, AM=2 36 (.), Moon	III – EN-410 AM=1 56(.)	IV – ISO-9050 2003, AM=1,5 95 (.)	V – ISO-9050 2003, AM=1,5 20 (.)
1	87	88	88	88	88
2	55	55	55	56	55
3	43	44	42	43	42
4	54	54	54	54	54
5	33	33	33	33	33
6	70	74	73	73	75
7	64	69	67	67	69
8	52	57	56	56	57
9	49	50	51	50	51
10	88	89	88	88,5	89

Table 1 Results of the solar direct transmittance calculations for some glass specimens according different standards

The analysis of the received results shows that for clear glass specimens (1, 10) or for glass specimens having approximately equal transmittance level in the whole research waveband (4, 5) and without transmittance reducing in long-wave range (9) used standard type is no principal object: maximal difference (and only for specimen 9) is no more than 2%. The difference in calculations with using “new” ISO-9050 (2003) and his simplified variant ISO not exceeds 1% for such glass types. Data difference between “new” ISO-9050 and EN-410 is no more than 1% also. More essential difference in calculation results emerged only for those specimens that have lower transmittance to the infrared region direction. Maximal difference for them is 5%. Generally most important discrepancies are observed at comparison of data obtained by ISO-9050 (1990, CIE) and ISO-9050 (2003) (although large discrepancy deviations are between two variants of “old” ISO 1990 – between CIE and Moon), the difference between two

variants of “new” ISO (with 95 and 20 points) works out 2%, the difference between ISO-9050 (2003) and EN-410 – 1%.

Conclusions

Thus, obtained results allow summarizing, that calculations by means of two most applicable modern standards – ISO-9050 (2003) and EN-410 have no principal difference. Also it may be concluded, that calculations by means of simplified variant of ISO -9050 (2003) are quite permissible, especially for clear glasses. The exception takes place in the cases, when special accuracy is need or when glass spectra reveal intense select absorption.
In addition let us note that it may be put on the question about full acceptance of last variant of ISO-9050 (2003) for all Russia regions. The problem consists in the following: the adopted spectral distribution of global solar irradiation used in this standard mostly corresponds to geographical dislocation of USA (30°-50°) and West Europe (40°-55° of north latitude) territories. Russia territory mostly disposes at more northern latitudes (50°-70°) and even up to 80° (Taimyr Peninsula or Nenets Autonomous Area). So the equity of calculations by means of ISO-9050 (2003) for all Russia regions must be considered separately.

Notes

*Air mass (AM) – Ratio of the mass of atmosphere in 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
** Analogous data for the calculation of solar direct transmittance are contained in DIN 67507.

References

[1] Publication CIE No. 20 (TC-2.2), Recommendation for the integrated irradiance on the spectral distribution of simulated solar radiation, Paris 1972.

[2] Publication CIE No. 85, Solar spectral irradiance, technical report (1989).

[3] Proposed standard solar-radiation curves for engineering use. P. Moon, J. Franklin Inst., 203, 583-618.

[4] ISO 9050: 1990, Glass in building – Determination of light transmittance, solar direct transmittance, total solar energy transmittance and ultraviolet transmittance, and related glazing factors.

[5] ISO 9050: 2003, Glass in building – Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance, and related glazing factors.

[6] EN 410: 1998, Glass in building – Determination of luminous and solar characteristics of glazing.

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