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Glass in building — Electrochromic glazings — Accelerated ageing test and requirements

Verre dans la construction — Vitrages électrochromes — Essai de vieillissement accéléré et exigences

Reference number
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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 160, *Glass in building*, Subcommittee SC 1, *Product considerations*.

This second edition cancels and replaces the first edition (ISO 18543:2017), which has been technically revised.

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

— the document has been restructured;

— the acceptance criteria for the two classes has been revised;

— fast switching products have been taken into account;

— the concept of photopic transmittance ratio has been abandoned in favour of the one of 85 % of the dynamic range;

— other types of lamps have been allowed provided that they simulate correctly the solar irradiation.

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

Electrochromic glazings perform several important functions in a building envelope, including

— minimizing the solar energy heat gain,

— providing for passive solar energy gain,

— controlling a variable visual connection with the outside world,

— enhancing thermal comfort (controlling heat gain), energy efficiency performance, illumination, and glare control, and

— providing for architectural expression.

Therefore, it is important to understand the relative serviceability of these glazings.

This document is intended to provide a means for evaluating the durability of electrochromic glazings.

The test procedures covered in this document includes:

a) rapid but realistic cycling between high and low light transmission states;

b) environmental parameters that are typically used in weatherability tests such as simulated solar exposure and high temperature, which are realistic for the intended use of electrochromic glazings.

Glass in building — Electrochromic glazings — Accelerated ageing test and requirements

1 Scope

This document specifies the accelerated ageing test and requirements for electrochromic glazings intended to either control direct or indirect solar transmission, or both. The electrochromic glazings can be assembled as insulating glass unit, laminated glass or combination of both.

The test method described in this document is only applicable to chromogenic glazings that can be switched between different transmission states using an electrical stimulus. This test method is not applicable to other chromogenic glazings such as photochromic and thermochromic glazings, which do not respond to electrical stimulus.

This test method is applicable to any electrochromic glazing fabricated for use in buildings such as in doors, windows, skylights, exterior wall systems and glazing exposed to solar radiation. The materials used for constructing the electrochromic glazing and for electrochromically changing its optical properties can be inorganic or organic 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 9050, *Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors*

ISO 12543 (all parts), *Glass in building — Laminated glass and laminated safety glass*

ISO 20492 (all parts), *Glass in buildings — Insulating glass*

3 Terms and definitions

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

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

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

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

3.1
chromogenic glazing
glazing that has the ability to reversibly change either its visible or solar transmission, or both, in response to an external stimulus such as electrical voltage or current, solar radiation or temperature

Note 1 to entry: Active components can be films, coatings, glasses or a combination of them.

3.2
electrochromic glazing
chromogenic glazing (3.1) in which an applied voltage or current is used to reversibly modify either visible or solar transmission characteristics, or both

Note 1 to entry: Active components are usually films, coatings or a combination of them.

3.3
highest transmission state
highest visible light transmittance achieved by the *electrochromic glazing* (3.2)

3.4
lowest transmission state
lowest visible light transmittance achieved by the *electrochromic glazing* (3.2)

3.5
switching time
time taken for *electrochromic glazing* (3.2) to transition to or from the highest and *lowest transmission states* (3.4)

Note 1 to entry: The time to go from the *lowest transmission state* (3.4) to the *highest transmission state* (3.3) can be different from the time needed for the reverse transition.

3.6
switching cycle
transition in light transmittance between two defined light transmittance values starting and ending back at the same point

3.7
lateral uniformity
degree of variation in the amount of irradiance in the x and y directions in the test plane used for exposing *electrochromic glazing* (3.2)

4 Symbols

$V(\lambda)$	spectral luminous efficiency for photopic vision defining the standard observer for photometry (see ISO 23539:2005[1])
τ	visible light transmittance
τ_H	visible light transmittance in the highest transmission state
τ_L	visible light transmittance in the lowest transmission state
t_L	switching time to reduce the transmittance of the glazing
t_H	switching time to increase the transmittance of the glazing
t_{cycle}	total cycle time

Subscripts:

i	initial stage, prior to accelerated ageing
f	final stage, after accelerated ageing
85	related to 85 % of the difference between the highest transmission state and the lowest transmission state

5 Principle of the test

This test method compares light transmittance before and after artificial ageing.

The electrochromic glazings shall be exposed to simulated solar radiation during 5 000 h in a temperature-controlled chamber at specimen temperatures as defined in Table 1. During this exposure, the sample shall be switched to at least 85 % of its dynamic range, i.e. the difference between the highest transmission state and the lowest transmission state, with the shortest possible switching cycle, see Formula (1).

$$\tau_{L,85} = \tau_H - 0{,}85 \times (\tau_H - \tau_L) \quad (1)$$

In case the switching time is such that more than 50 000 cycles are performed in 5 000 h, an adapted switching cycle may be used, see 8.3.

Table 1 — Test classification summary

Conditions of testing	Class 1	Class 2
Specimen temperature	(85 ± 7) °C	(65 ± 7) °C
Number of switching cycles	Maximum possible with a maximum of 50 000 cycles	Maximum possible with a maximum of 50 000 cycles
Number of hours of exposure	5 000 h	5 000 h
NOTE Class 2 is for electrochromic glass that are not able to switch when above 65 °C.		

The procedure consists of the following steps:

— step 1: initial characterization of the test sample and determination of the cycling conditions:

— light transmittance at highest ($\tau_{H,i}$) and at lowest ($\tau_{L,i}$) transmission states, at room temperature;

— switching time from highest to lowest transmission states ($t_{L,i}$) and reverse ($t_{H,i}$), at room temperature;

— switching time of 85 % of the dynamic range in both directions, at the selected test temperature;

— calculation of the total switching cycle to be used in step 2;

— step 2: cycling and radiation exposure of the test sample in a chamber maintained at the selected test temperature;

— step 3: final characterization of the test sample:

— light transmittance at highest ($\tau_{H,f}$) and at lowest ($\tau_{L,f}$) transmission states, at room temperature;

— switching time from highest to lowest transmission states ($t_{L,f}$) and reverse ($t_{H,f}$), at room temperature.

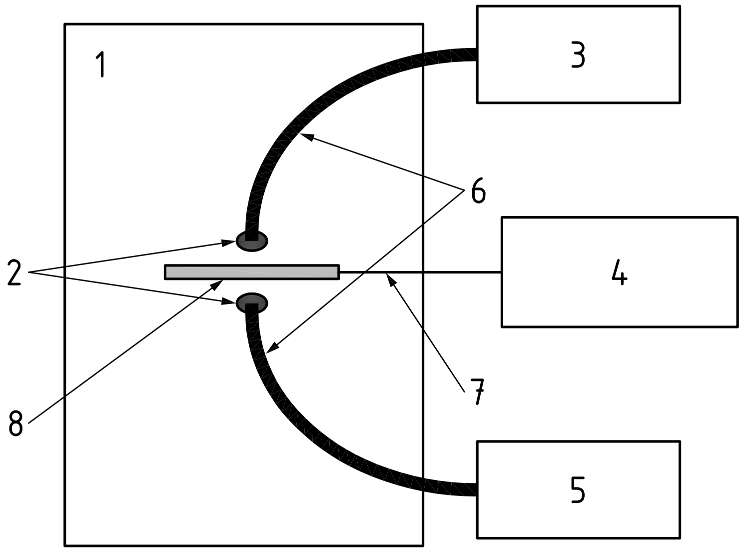
When compared to the initial characteristics, the final characteristics shall meet the requirements given in Clause 9.

6 Description of the test equipment

6.1 Oven (for steps 1 and 3)

An oven shall be used to carry out optical measurements and to define the switching cycle of the electrochromic glazings at the requested temperatures. It shall be large enough for the largest electrochromic glazing to be tested and shall be able to reach the electrochromic glazing testing temperature. The oven shall also be designed to permit using the equipment described in 6.2 and 6.3 for optical measurements while the electrochromic glazing shall be maintained at the temperature chosen for step 2. Thermocouples shall be used to measure specimen temperature in the oven.

A schematic of an oven is given in Figure 1.



Key

1	convection oven
2	lens
3	spectrometer lamp source
4	electrochromic switching control system
5	spectrometer
6	spectrometer fibre optic cables
7	thermocouple and electrical leads
8	electrochromic sample

Figure 1 — Schematic of an oven used to determine the switching cycle for use in the test chamber — Plan view

6.2 Spectrometer (for steps 1 and 3)

A spectrometer shall be used for obtaining and storing data from the optical characterization in the range 380 nm to 780 nm of the specimens in the highest and lowest transmission states.

The lamp source can be a tungsten lamp or other lamp source that provides illumination from 380 nm to 780 nm.

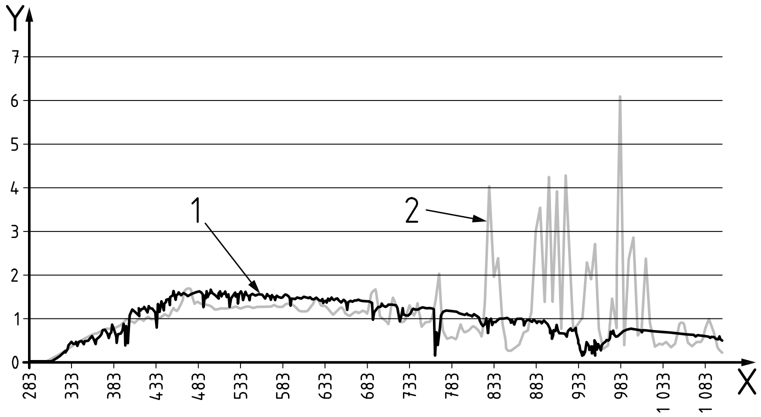
Fibre optic cables extend from the lamp source into the electrochromic glazing specimen holder and from the electrochromic glazing specimen holder to the spectrometer. One optical fibre guides the incident light from the lamp source to one side of the specimen; another optical fibre guides the transmitted light to the spectrometer attached to a computer. The fibres shall be optically coupled by properly aligned collimating lens assemblies attached to both the illuminating and the collecting fibres.

6.3 Switching control system (for steps 1 and 3)

The switching to and from highest and lowest transmission states during spectrophotometer transmittance measurements can be done by means of a computer-controlled multichannel potentiostat or by manufacturer-supplied control system.

6.4 Test chamber (for step 2)

The test chamber shall be temperature-controlled and shall contain lamps that have been filtered appropriately in order to simulate the spectral power distribution of solar radiation over the ultraviolet, visible and near infrared wavelength regions. As an example, Figure 2 shows the spectral irradiance of an appropriately filtered xenon arc source compared to the global Air Mass 1,5 spectrum.



Key

X wavelength of the radiation in nm

Y irradiance in W · m^{-2} · nm^{-1}

1 spectral power distribution of Air Mass 1,5 solar irradiation

2 irradiance of an appropriately filtered xenon arc lamp which is used to simulate the spectral power distribution of solar radiation

Figure 2 — Irradiance of an appropriately filtered xenon arc lamp compared to the spectral power distribution of air mass 1,5 solar irradiation

NOTE 1 At longer wavelengths, the xenon arc emission is at variance with the air mass 1,5 solar spectrum because the intensities relative to those in the ultraviolet/visible region are higher than in solar radiation. However, this part of the spectrum does not cause photolytic-induced degradation.

To prevent unintended degradations, peaks occurring in the range 300 nm to 780 nm should be avoided.

Figure 3 shows an example top-view of the essential features of the test chamber, including the layout of the electrochromic glazings on a test plane, the location of the lamps above the test plane and the necessary connecting cables from the electrochromic glazings to the computer-controlled cycling and data acquisition system. Chamber dimension shall be large enough to accommodate all specimens.

The intensity of the irradiance at the specimens shall be adjustable to obtain the desired light intensity and lateral uniformity within the guidelines of this document (see 6.4).

NOTE 2 This can be achieved by adjusting the distance between the specimens and the lamps.