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Tableware, giftware, jewellery and luminaries, made of glass — Glass clarity — Classification and test method

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Contents

Page

Foreword

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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).

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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 Project Committee ISO/PC 320, *Tableware, giftware, jewellery and luminaries made of glass — Glass clarity — Classification and test method*.

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

This document intends to provide a generic definition and classification of glass clarity to permit a global understanding of consumer quality requirements, with a corresponding method to measure glass clarity.

For glass clarity, spectrophotometric measurement is performed in accordance with CIE 15 with a predefined choice of illuminate and observer. Measurement on the sample at two different thicknesses permits calculation of internal transmission for a defined intermediate thickness and indicates glass clarity irrespective of the refractive index value. The same methodology applies for all mineral glasses.

This method has been verified in accordance with visual inspection with a light cabinet. In addition, preliminary collaborative studies have confirmed the results of these measurements as being coherent with both consumer perception and quality recognition.

As it is well known that iron is by far the main contaminant of glass raw materials affecting the transparency and colorimetric purity of the glass, the iron content has been considered as an additional criterion.

This document does not concern lead crystal categories as defined in EU Council Directive 69/493/EEC, which has its own characteristics with respect to density and refraction index.

Tableware, giftware, jewellery and luminaries, made of glass — Glass clarity — Classification and test method

1 Scope

This document establishes requirements for the use of the glass designations “clear glass” and “ultra-clear glass” for non-coloured glass items according to their clarity and iron content. It specifies a procedure for measuring the clarity of glass items by means of a spectrophotometer.

This document is applicable to

— mineral glasses, and

— glass items where a part is not covered by coating or decoration, and is therefore available for sampling.

This document is applicable to the use of glass as tableware, giftware, jewellery and luminaries.

It is not applicable to the use of glass in the context of building, watches, containers, medicine and laboratories, and to other technical uses of glass.

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.

CIE 15, *Colorimetry*

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

4 Specifications

4.1 General

The classification of the samples of glass in terms of clarity is based on three criteria:

— lightness, L^*;

— chroma, C^*;

— iron content of the material.

The iron content is a main contaminant influencing the transparency and colour of the glass; the value is expressed in iron oxide (Fe_2O_3) in mg/kg.

NOTE The best classification of clarity is obtained for the maximum value of lightness L^* at 100 and the minimum value of chroma C^* at zero.

4.2 Specifications for ultra-clear glass

Ultra-clear glass shall have:

— lightness $L^* \geq 98{,}8$;

— chroma $C^* \leq 0{,}5$;

— iron oxide content ≤ 140 mg/kg.

If one or more of these criteria are not reached, the glass cannot be classified as ultra-clear glass.

4.3 Specifications for clear glass

Clear glass shall have:

— lightness $L^* \geq 98{,}0$;

— chroma $C^* \leq 0{,}5$;

— iron oxide content ≤ 200 mg/kg.

If one or more of these criteria are not reached, the glass cannot be classified as clear glass.

5 Test methods

5.1 General

The sample shall be prepared in accordance with 5.3 and 5.4. The same sample shall be used to characterize the three criteria, in accordance with the following two determination methods:

— Annex A shall apply for the determination of lightness L^* and chroma C^*;

— Annex B shall apply for the determination of the iron oxide content.

5.2 Apparatus

5.2.1 Double-beam spectrophotometer, preferably with integrating sphere.

5.2.2 X-ray fluorescence spectrometer, with wavelength dispersion.

5.2.3 Non-metallic hammer.

5.2.4 Non-metallic plate.

5.2.5 Platinum crucible, compatible with the final dimensions of the sample(s).

5.2.6 Electric oven, capable of maintaining a temperature of 1 300 °C for a duration of 16 h.

5.2.7 Polishing device.

5.2.8 Manual grinding device, with silicium carbide (SiC) abrasive.

5.2.9 Automatic grinding machine.

5.2.10 Automatic polishing device.

5.3 Sampling

5.3.1 General

The sampling is carried out to select one or two pieces of glass with:

— a minimum dimension of 30 mm between two parallel faces;

— a minimum dimension of 10 mm between two parallel faces.

The two other dimensions shall be greater than the slide dimensions of the spectrophotometer (5.2.1) for the one or two pieces.

5.3.2 Cutting

Cut a glass block from the glass item (such as tumblers with a thick bottom).

For glass items covered with coating or decoration, or for glass items of which the minimum dimensions of the sample cannot be reached:

a) melt a sufficient quantity of glass not covered with coating or decoration, approximately 200 g;

b) crush with a non-metallic hammer (5.2.3) on a non-metallic plate (5.2.4);

c) melt in a platinum crucible (5.2.5) in an electric oven (5.2.6) for a duration of at least 8 h at 1 300 °C, in order to obtain a good quality of glass;

d) check for the absence of seeds or bubbles;

e) after solidification of the glass, put the crucible outside the furnace in a cold-water stream to separate the glass from the crucible. The resulting sample is annealed to avoid residual stresses. Alternatively, the crucible and glass can be annealed and drilled with the core drill and core removed for cutting and polishing.

5.4 Sample preparation

5.4.1 General

For the internal transmission measurements, prepare one or two samples with at least one dimension of 10 mm and another one of 30 mm thickness for measurement between two parallel faces (see 5.3.1). The sample thicknesses where the light travels are (10 ± 0,05) mm and (30 ± 0,05) mm respectively.

The dimensions of the samples should fit the sample holder of the spectrophotometer that is used.

The preparation of the glass samples is carried out in accordance with the usual procedures of the laboratories, applying a polishing device (5.2.7) on the two faces in the optical way of transmission (light path).

5.4.2 Cutting

Each sample is cut from the part of a glass block that is homogenous and free of bubbles, cords and any other defects, by means of a diamond saw, to dimensions that are

— approximately 0,5 mm greater than the required final dimensions before manual grinding with silicon carbide abrasive (see 5.2.8), or

— approximately 5 mm greater than the required final dimensions before grinding with an automatic machine as used in the glass industry (see 5.2.9).

5.4.3 Grinding

In the manual grinding procedure, a sample is ground under flowing water to obtain parallel surfaces at each measured face by means of turning grinding disks (see 5.2.8), using coarse grain size of silicon carbide granules. The final step of grinding is carried out on a flat glass surface, using fine grain size of silicon carbide (less than 25 µm) polishing slurry to obtain the exact final dimensions of the samples and the right surface appearance. With a grinding machine (see 5.2.9), the sample is ground automatically by 1,5 mm steps (or less). The sample is machined on one side and then on the other side to obtain parallel sides. The thickness is then reduced to 10 mm or 30 mm.

In both procedures (manual and automatic), the parallelism of the surfaces and the dimensions are continuously checked between the grinding steps.

5.4.4 Polishing

Only the two surfaces of the glass sample from where the light travels in the spectrophotometer shall be polished.

In the manual procedure, the samples are polished on a turning polishing wheel (see 5.2.7) using cerium oxide powder solution, obtained by diluting approximately 100 g of powder with 500 ml of water.

Polishing can also be achieved automatically by a polishing machine using cerium oxide (as used in the glass industry) (see 5.2.10).

Lastly, a verification is made so that the thickness is within the tolerance of ± 0,05 mm, as is the parallelism of the ground and polished sample deviation range of the required dimensions. The polished sample is cleaned using alcohol before the measurement.

Only glass samples without optical distortion and surface defects shall be used on the polished surfaces.

NOTE Optical distortion is checked by viewing a grid through the glass sample. If there are bubbles or any other defects, deviation and distortion of the observed image occur.

Annex A
(normative)

Determination of the lightness L^* and chroma C^*

A.1 Applicability

The procedure in this annex describes a method for determining lightness L^* and chroma C^*, in order to classify glass items in accordance with the specifications for ultra-clear glass (see 4.2) and for clear glass (see 4.3).

This procedure applies to samples prepared in accordance with 5.3 and 5.4.

A.2 Principle

Spectrophotometric measurement is performed in accordance with CIE 15 with a predefined choice of illuminate and observer.

The total transmission of the samples is measured in order to calculate the internal transmission. The colorimetric values are then calculated from internal transmission data.

A.3 Measurement of lightness L^* and chroma C^*

A.3.1 General

The spectral curves of total transmittance (internal and surface) are measured every 5 nm on the spectral range from 380 nm to 780 nm on the sample, with the two thicknesses of 10 mm and 30 mm, using a double-beam ultraviolet-visible (UV-Vis) spectrophotometer (see 5.2.1).

Geometry (transmittance/reflectance) 0°/8°, reference: air. Temperature of the room: (22 ± 2) °C.

The laboratory shall take the necessary actions to maintain an adequate level of calibration of the equipment.

A.3.2 Calculation of the internal transmission

A.3.2.1 Principle

Measurement on the sample at two different thicknesses permits calculation of internal transmission for a defined intermediate thickness and indicates glass clarity irrespective of the refractive index value.

A.3.2.2 Total transmittance measurement, T_λ

Measure the total transmittances $T_{\lambda,d1}$ and $T_{\lambda,d2}$ of the sample at two different thicknesses, d_1 and d_2, in order to determine the transmittance of a thickness x, as $d_1 < x < d_2$ (see A.3.1).

For the purposes of this document, use d_1 = 10 mm and d_2 = 30 mm, with x = 20 mm (see A.3.1).

A.3.2.3 Calculation of the extinction coefficient, K_λ

The extinction coefficient, K_λ, is calculated as shown in Formula (A.1):

$$K_\lambda = -\frac{\ln\left(\frac{T_{\lambda,d1}}{T_{\lambda,d2}}\right)}{d_1 - d_2} \tag{A.1}$$

where

K_λ is the extinction coefficient at the wavelength λ;

$T_{\lambda,d1}$ is the transmittance value of the glass item sample of thickness d_1 (10 mm) at wavelength λ;

$T_{\lambda,d2}$ is the transmittance value of the glass item sample of thickness d_2 (30 mm) at wavelength λ.

A.3.2.4 Calculation of the internal transmission, $T_{i\lambda}$, for a chosen thickness (20 mm)

From the extinction coefficient (see A.3.2.3), the internal transmission, $T_{i\lambda}$, is calculated as shown in Formula (A.2):

$$T_{i\lambda} = \frac{\Phi_{i\lambda}}{\Phi_{e\lambda}} = e^{-K_\lambda \chi} \tag{A.2}$$

where

χ is the chosen thickness (20 mm);

$T_{i\lambda}$ is the internal transmission;

$\Phi_{i\lambda}$ is the light flow with the wavelength λ entering in an isotropic element, non-luminescent, non-phototropic and optically clear;

$\Phi_{e\lambda}$ is the outgoing light flow.

A.3.3 Calculation of lightness L^* and chroma C^*

From the obtained spectral curve of internal transmittance, the colorimetric values are calculated in colour space developed by the International Commission on Illumination (CIE) in CIE 1976 (CIELAB) (see ISO/CIE 11664-4), in Cartesian coordinates $L^*a^*b^*$ and in cylindrical coordinates L^*C^*h, for

— the main reference illuminate D65 (see ISO 11664-2), and

— the observer 10° (see ISO/CIE 11664-1).

All colorimetric calculations are carried out in accordance with the recommendations of CIE 15.

NOTE These colour measurements can be validated and correlated with visual observations under light cabinet, with an illuminate D65 and under an illumination of 1 000 lx, and on a grey and uniform back of lightness $L^* = 50$.

D65 is the reference illuminate. It is advisable that the user of this document take into consideration the possible effects of a measurement under another illuminate.

See Annex C for the estimation of the experimental reproducibility.

Annex B
(normative)

Determination of the iron oxide content

The iron content of the material is also taken into consideration, according to the value of the iron content [expressed by convention as iron oxide (Fe_2O_3)] as measured by X-ray fluorescence in the same glass samples.

For the X-ray fluorescence calibration and measures, refer to the publications listed in the Bibliography and use certified standard material.

Standard materials are currently available from the German Federal Institute for Material Research and Testing[1)]. Other certified standard materials are also available.

If appropriate certified standard materials are not available in the laboratory, chemical methods shall be employed.

1) Bundesanstalt für Materialforschung und -prüfung (BAM). This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Annex C
(informative)

Estimation of the experimental reproducibility

One laboratory performed 10 measurements of the same sample on 10 different days with the same instrument and operator. The obtained standard deviations of the measurements are as follows:

— standard deviation on lightness L^* = 0,028;

— standard deviation on chroma C^* = 0,026.

A round robin test was performed by seven laboratories. The average values of lightness L^* and chroma C^* were determined on 17 different samples covering a large range of glasses on the market. The standard deviations for these values were obtained. The main results are given in Table C.1.

Table C.1 — Reproducibility study for the determination method in Annex A

Parameters	Range of measurement	Standard deviation
Lightness L^*	From 97,1 to 99,7	From 0,06 to 0,15
Chroma C^*	From 0,07 to 0,53	From 0,01 to 0,08

Bibliography

[1] ISO/CIE 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

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[4] ASTM E1172-16, *Standard Practice for Describing and Specifying a Wavelength-Dispersive X-Ray Spectrometer*

[5] ASTM E1361-02 (2014), *Standard Guide for Correction of Interelement Effects in X-Ray Spectrometric Analysis*

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[7] ASTM E1622-94 (1999)e1[3)], *Standard Practice for Correction of Spectral Line Overlap in Wavelength- Dispersive X-Ray Spectrometry*

[8] KIPPHARDT H, MATSCHAT R, "Traceability and uncertainty of chemical measurement results exemplified in the frame of the certification and the use of the glass CRM BAM-S005", in: Rivista della Stazione Sperimentale del Vetro, 2007, vol. 37, No. 6, pp.19-23

2) ISO 11664-2 is identical to CIE S 014-2.

3) Withdrawn (2006).

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