SLOVENSKI STANDARD
SIST ISO 12775:1998

01-april-1998

Navodila za vrste stekel normalne sestave in njihove preskusne metode

Guidelines on types of glass of normal bulk-production composition and their test methods

Lignes directrices sur les types de verre de composition normale de production en vrac et leurs méthodes d'essai

Ta slovenski standard je istoveten z: ISO 12775:1997

ICS:

81.040.01 Steklo na splošno Glass in general

SIST ISO 12775:1998 **en**

INTERNATIONAL STANDARD

ISO 12775

First edition
1997-10-15

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Reference number
ISO 12775:1997(E)

Contents

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Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 12775 was prepared by Technical Committee ISO/TC 48, *Laboratory glassware and related apparatus,* Subcommittee SC 5, *Quality of glassware.*

Annex A of this International Standard is for information only.

Introduction

Various committees have been working for many years at national and international levels to produce agreed test methods for measuring the chemical and physical properties of glass as a material and glassware as finished articles. Because the international standardization part of the work has mostly been carried out under the aegis of the International Organization for Standardization, through its Technical Committee ISO/TC 48, *Laboratory glassware and related apparatus*, the aim of the work has always been slanted towards this type of ware. Even so, the test methods and classifications proposed to date are equally applicable to other kinds of glass and to glassware which is not necessarily used only for laboratory purposes.

It has been suggested that a collection of the information produced by the various committees would provide useful guidance to users and to manufacturers of glassware. This International Standard is, therefore, intended to give such guidance but it is strongly emphasized that a classification according to one test procedure is not necessarily related to classification by another test procedure.

Although not concerning normal bulk-production glass, Technical Committee ISO/TC 172, *Optics and optical instruments*, has established some International Standards for test procedures for optical glass, for example for acid resistance (ISO 8424) and for testing the resistance to attack by aqueous alkaline phosphate-containing detergent solutions (ISO 9689).

To make these guidelines complete, some test methods are also cited which do not have a classification (which is needed for most physical test methods) but that are sometimes of great interest for the glass user or glass manufacturer.

Guidelines on types of glass of normal bulk-production composition and their test methods

1 Scope

This International Standard establishes a survey of glass types and of methods for testing their chemical and physical properties to give, for example, consumers and producers of glass of normal bulk-production composition the possibility to compare the different types of glass and test methods and to decide which are of interest for a special demand or use. For this purpose, these comprehensive guidelines give a classification of the different glass types of normal bulk-production composition according to the chemical composition and indicate the different test methods and, where they exist, the classifications according to chemical resistance.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standard are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 695:1991, *Glass — Resistance to attack by a boiling aqueous solution of mixed alkali — Method of test and classification.*

ISO 718:1990, *Laboratory glassware — Thermal shock and thermal shock endurance — Test methods*.

ISO 719:1985, *Glass — Hydrolytic resistance of glass grains at 98 °C — Method of test and classification*.

ISO 720:1985, *Glass — Hydrolytic resistance of glass grains at 121 °C — Method of test and classification*.

ISO 1776:1985, *Glass — Resistance to attack by hydrochloric acid at 100 °C — Flame emission or flame atomic absorption spectrometric method.*

ISO 3585:1991, *Borosilicate glass 3.3 — Properties*.

ISO 4802-1:1988, *Glassware — Hydrolytic resistance of the interior surfaces of glass containers — Part 1: Determination by titration method and classification*.

ISO 4802-2:1988, *Glassware — Hydrolytic resistance of the interior surfaces of glass containers — Part 2: Determination by flame spectrometry and classification*.

ISO 4803:1978, *Laboratory glassware — Borosilicate glass tubing.*

ISO 7459:1984, *Glass containers — Thermal shock resistance and thermal shock endurance — Test methods*.

ISO 7991:1987, *Glass — Determination of cœfficient of mean linear thermal expansion*.

3 Main types of glass of normal bulk-production composition

The main types of glass of normal bulk-production composition are classified in table 1.

NOTE — In many cases it is customary to divide glass into different " types " according to the use or shape (laboratory glass, bottle glass, optical glass, flat glass, hollow glass) and in a general way this division is a kind of classification. Another possibility is a classification according to the chemical composition. This leads to the types listed in table 1, which of course cannot be absolutely pure concerning the composition ranges.

Table 1 — Classification of main types of glass of normal bulk-production composition according to their chemical composition

Descriptors	Alkali/alkaline earth/silicate glass[1]	Borosilicate glass		Alkaline earth/alumino-silicate glass	Alkaline lead silicate glass
		Alkaline-earth free (Borosilicate glass 3.3)[2]	Containing alkaline earths (Known as "neutral glass"[3]		
Key oxides % (*m/m*)	Na_2O, CaO > 10	B_2O_3 > 8	B_2O_3 > 8	Al_2O_3 > 10	PbO > 10
Typical field of composition					
SiO_2 % (*m/m*)	70 to 75	≈ 81	≈ 75	52 to 60	54 to 58
Alkali oxides ($Na_2O + K_2O$) % (*m/m*)	12 to 16	≈ 4	4 to 8	—	up to 15
Alkaline-earth oxides % (*m/m*) (MgO + CaO + BaO + SrO)	10 to 15	—	up to 5	up to 15	up to 4
Al_2O_3 % (*m/m*)	0,5 to 2,5	2 to 3	2 to 7	17 to 25	up to 4
B_2O_3 % (*m/m*)	—	12 to 13	8 to 12	—	—
PbO % (*m/m*)	—	—	—	—	up to 35
Cœfficient of mean linear thermal expansion, $10^{-6}K^{-1}$ α (20 °C; 300 °C)	8 to 10	3,3	4 to 5	≈ 4	7 to 9
Hydrolytic resistance Acid resistance Alkali resistance	Medium, low Very high Medium	Very high Very high Medium	Very high Very high Medium	High, very high Low Low	Medium Low, medium Medium
Main fields of application	Container bottle (glass); float glass; drawn sheet glass	Laboratories for chemical, pharmaceutical and food industries[4] Technical purposes with demands for high chemical and thermoshock resistance	Pharmaceutical containers Technical purposes with demands for high chemical resistance	Purposes with demands for high thermal resistance: high-temperature thermometers, resistors capable of high thermal and electrical loading, combustion tubes	Noble table glasses; lamp stems; cathode ray tubes; radiation-shielding glass

NOTE — The given compositions are mean levels of typical glass types. They are only for information and shall not be understood as "limit values. It is known that actual glasses differ to a certain degree, which does not affect the chemophysical properties.

1) This is the oldest glass type, which makes the largest percentage of the worldwide glass production; also belonging to this type are glasses with higher BaO and SrO contents such as alkaline-earth oxides, with reduced alkali content (e.g. for X-ray protection, as used in cathode ray tube components), and also certain crystal glasses (drinking glasses).

2) In accordance with ISO 3585.

3) See ISO 4802-1 and ISO 4802-2.

4) See ISO 4803.

4 Chemical properties of glass and glass articles

4.1 General

The chemical durability, or chemical resistance, of glass as a material or of glass articles is the ability of the exposed surfaces to withstand attack by acid, neutral or alkaline solutions. In general for silicate glasses this ability decreases with increasing alkalinity of the attacking medium and test methods are available for measuring these resistances.

4.2 Glass as a material and glass as-delivered

When properties of glass articles are considered, it must be emphasized that the surface of a finished glass article can have different properties than the glass itself, called "glass as a material". This glass as a material (i.e. the bulk glass) has, of course, the same properties as the glass of glass articles when their surface layers are removed, for instance by grinding, or polishing, or acid etching with hydrofluoric acid. But the properties of glass surfaces can be modified: for instance, fire-polishing by pressing or blowing creates a slightly different surface layer because of the evaporation of glass substituents at the glass-forming temperature. Also the glass surface can be treated when the articles are finished: ion-exchange (salt melts, for instance) can result in a strengthening effect; or acid vapour (such as SO_2) can reduce the alkali concentration in the surface of soda-lime glasses, and thus their surfaces show a better hydrolytic resistance; there are many other examples.

So when glass articles are tested, care shall be taken to define whether the surface is tested "as-delivered" (i.e. with the original surface layer) or "as a material", which is to be achieved by acid etching, grinding/polishing or breaking. The qualitative descriptions of the types of glass in tables 2 and 3 concern glass as a material only; tables 4 to 6 concern non-treated glasses/articles except for class HC 2 in ISO 4802 (in tables 4 and 5).

4.3 Test methods

4.3.1 Hydrolytic resistance (see ISO 719, ISO 720, ISO 4802-1 and ISO 4802-2)

Grain tests, such as described in ISO 719 and ISO 720, measure the resistance of glass as a material to attack by neutral solutions (i.e. water) and this is called the "hydrolytic grain resistance". These tests apply to glass as a material because the sample is broken and new bulk surfaces are produced.

The hydrolytic resistance of glass containers is measured by a "whole article" test in which the container is filled with water and the resistance of the "as-produced" surface is measured.

NOTE — The European Pharmacopœia uses the latter type of test to measure the performance of containers and the former to distinguish between the resistances imparted to glass by compositional and surface treatment processes.

The values given in table 4 show the limiting titration values required to neutralize 100 ml of extraction solution from various capacities of containers, as given in ISO 4802-1.

NOTE — The values for container classes HC 1, 2 and 3 are indentical to those published by the European Pharmacopœia, where they are called "glass container types". Since there are more container types, ISO 4802 includes also the container class HC B (a glass used especially for "buvables", i.e. drinking ampoules and vials) and HC D (for "dry substances").

Furthermore, a classification according to the direct determination of the released alkali, different from the determination of the sum parameter of hydroxide ions by titration (as done by flame spectrometric methods on the extract solution) is given in ISO 4802-2 (see table 5). A direct conversion from one system to the other (titration to flame-spectrometric values) is not clear nor easily achievable, but a conversion factor between 2,5 and 3,0 was proved by interlaboratory tests to be true, so long as the values are near the limits between the container classes.

4.3.2 Acid resistance (see ISO 1776)

The resistance of glass articles to attack by acid solutions (usually 6 mol/l hydrochloric acid) can be measured by the procedure described in ISO 1776. In this procedure the glass sample is prepared in the form of a piece, of 30 cm^2 to 40 cm^2 surface area. When the area of the cut edges does not exceed 10 % of the total surface area, the pieces can be regarded as tested as-delivered. When the area of the edges is greater than 10 %, the rest of the original surfaces shall be removed for the acid resistance test in accordance with ISO 1776 by acid etching and