

BS EN ISO 4611:2010



BSI Standards Publication

Plastics — Determination of the effects of exposure to damp heat, water spray and salt mist (ISO 4611:2010)

bsi.

...making excellence a habit.™

English Version

**Plastics - Determination of the effects of exposure to damp heat,
water spray and salt mist (ISO 4611:2010)**

Plastiques - Détermination des effets d'une exposition à la
chaleur humide, au brouillard d'eau et au brouillard salin
(ISO 4611:2010)

Kunststoffe - Bestimmung des Verhaltens bei Einwirkung
von warmfeuchtem Klima, Sprühwasser und Salznebel
(ISO 4611:2010)

This European Standard was approved by CEN on 14 December 2010.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Foreword

This document (EN ISO 4611:2010) has been prepared by Technical Committee ISO/TC 61 “Plastics” in collaboration with Technical Committee CEN/TC 249 “Plastics” the secretariat of which is held by NBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2011, and conflicting national standards shall be withdrawn at the latest by June 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 4611:2008.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 4611:2010 has been approved by CEN as a EN ISO 4611:2010 without any modification.

Contents

Page

Foreword	iv
0 Introduction.....	v
1 Scope	1
2 Normative references	1
3 Principle	1
4 General test conditions.....	2
4.1 Equipment requirements	2
4.2 Exposure conditions	3
4.3 Test specimens (see 5.2, 6.2 and 7.2)	5
5 Change of mass	5
5.1 General	5
5.2 Test specimens.....	6
5.3 Conditioning	7
5.4 Procedure	7
5.5 Expression of results	7
6 Change of dimensions and appearance	7
6.1 General	7
6.2 Test specimens.....	8
6.3 Conditioning	8
6.4 Procedure	8
6.5 Expression of results	8
7 Change of other physical properties	9
7.1 General	9
7.2 Test specimens.....	9
7.3 Conditioning	9
7.4 Procedure	10
7.5 Expression of results	10
8 Test report.....	10
Annex A (informative) Absorption of moisture by a test specimen of a plastics material in equilibrium with its conditioning atmosphere	11
Bibliography.....	12

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 4611 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

This fourth edition cancels and replaces the third edition (ISO 4611:2008), which has been technically revised. The main changes concern the equipment requirements and exposure conditions specified in Clause 4.

0 Introduction

0.1 Various test methods are available for the exposure of plastics to different aggressive agents acting in a combined and simultaneous fashion, such as natural weathering. Other test methods are available for the purpose of a separate evaluation of the action of individual aggressive agents. Among the latter there are, for example, tests for the resistance to specific chemicals and to radiations of a definite spectral range.

For some applications, it may be desirable to evaluate the behaviour of the materials in a hot damp atmosphere just below the saturation limit of water vapour, as well as in the presence of the liquid phase.

In these conditions not only water absorption or leaching of some ingredients of the composition may be observed but also degradation phenomena due to hydrolysis, exudation of plasticizers, etc.

It may also be desirable sometimes to evaluate the behaviour of materials in the presence of a highly corrosive electrolyte, such as a sodium chloride solution (salt mist), which is the principal aggressive agent present in marine environments and of particular importance in the case of nautical applications. It is well known that sodium chloride has no noticeable action on the polymers that are the basic components of plastics, and that salt solutions, owing to their higher osmotic pressure, are normally absorbed by plastics to a lesser degree than pure water, but it cannot be assumed *a priori* that they have no action on composite materials, containing fillers, reinforcing components or pigments, for instance.

Furthermore, the evaluation of the effect of salt mist can be very important for finished or semi-finished articles which, while basically consisting of plastic materials, do contain some metallic elements, such as moulded-in inserts, thin laminated foils, surface coatings applied by electro-plating or other procedures, or, lastly, metal cores sheathed with plastics by extrusion or by dipping in pastes or fluidized-bed powders.

0.2 Methods and equipment for obtaining reproducible aggressive environments of the above types are well known and have been described by International Standards relevant to other materials and IEC (International Electrotechnical Commission) standards relevant to electrical and electronic components. The same equipment and procedures described in these standards can also be employed for plastics, with appropriate care and adjustments.

0.3 The present International Standard is intended to provide general guidance only, on the choice of suitable equipment and procedures for obtaining the exposure conditions described above and for the preparation of test specimens. It also only gives general guidance on the properties to be evaluated. Specific details are given in the various ISO and IEC publications.

For the expression of results, the present International Standard follows, as far as possible, the same criteria adopted in the existing test methods for the exposure to chemicals (see ISO 175) and to natural weathering or artificial light (see ISO 4582).

0.4 These tests are intended to yield data about the effects of the described exposures on the materials; however, a direct correlation between the experimental results and the behaviour in service is not to be inferred.

Plastics — Determination of the effects of exposure to damp heat, water spray and salt mist

1 Scope

1.1 This International Standard specifies the conditions of exposure of plastics to

- damp heat,
- water spray,
- salt mist,

and the methods for the evaluation of the change in some significant characteristics after given exposure stages.

1.2 This International Standard is, in general, suitable for all plastics in the form of standard test specimens, and finished articles or parts thereof.

1.3 This International Standard considers separately methods for the determination of

- change in mass,
- change in dimensions and appearance,
- change in physical properties.

2 Normative references

The following referenced documents are indispensable for the application 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 62, *Plastics — Determination of water absorption*

3 Principle

One or more properties are determined before and after given periods of exposure in the specified environmental conditions, and any change in appearance is observed. If required, the determination of one or more properties may be carried out after exposure and a subsequent drying treatment or a reconditioning treatment carried out with the aim of obtaining the same state of equilibrium with atmospheric humidity as that of the initial specimens.

4 General test conditions

4.1 Equipment requirements

4.1.1 General

Equipment used for exposing specimens to steady state or cyclic exposure conditions involving heat, humidity, and water or salt spray shall be made from corrosion resistant materials that will not interact with or contaminate the specimens being exposed. In addition, the device shall provide a means to programme and time the various portions of the exposure cycles that are used.

Sensing devices for measurement of temperature and relative humidity shall be located within the working volume of the chamber.

Any condensed water shall be continuously drained from the chamber and not re-used until re-purified.

No condensed water from the walls or roof of the chamber can fall on the test specimens.

Water used for the maintenance of the chamber humidity shall have a resistivity of at least 0,05 MΩ cm.

For the water spray (see 4.2.2) and salt mist (see 4.2.3) tests, the following additional equipment requirements shall be met. The cabinet shall have a volume of not less than 0,4 m³ since, with smaller volumes, difficulties have been experienced in ensuring an even distribution of spray. For large-volume cabinets, it is nevertheless necessary to ensure that the spray is distributed homogeneously throughout the cabinet. The upper parts of the inside of the cabinet shall be designed so that any drops of spray which form on its surface cannot fall on the specimens being tested.

For the salt mist test (see 4.2.3), the apparatus should, for environmental reasons, preferably be fitted with equipment for treating the salt mist after the test, prior to releasing it to the atmosphere, and also with equipment for treating the salt water produced during the test, prior to discharging it to the sewage system.

For the water spray (see 4.2.2) and salt mist (see 4.2.3) tests, the device for spraying the water or salt solution shall include a supply of compressed air, a reservoir containing the water or salt solution to be sprayed, and one or more atomizers. Before it reaches the atomizers, the compressed air shall be passed through a filter to remove all traces of oil and solid matter, and the atomization shall be carried out at an overpressure of about 70 kPa. The level of the water or salt solution shall be maintained automatically. In order to prevent evaporation of water from the sprayed droplets, the compressed air shall be humidified, before entering the atomizer, by passing it through a saturation tower containing distilled or deionized water at a temperature 10 °C above that of the cabinet.

For the salt mist test (see 4.2.3), the characteristics of the mist produced will depend on the pressure used and on the type of atomizer nozzle. These shall be adjusted so that the concentration of the salt mist in the cabinet (as measured by the rate of deposition of the mist on a collection surface) and the salt concentration in the mist are kept within the limits specified in 4.2.3.

NOTE ISO 9142:2003, Annex E, describes exposure conditions similar to those used in this International Standard.

4.1.2 Temperature

The exposure cabinet shall be capable of controlling the temperature in the exposure chamber to within ± 2 °C of the desired equilibrium temperature. The temperature tolerance limits of ± 2 °C are intended to allow for any systematic measurement errors, any temperature drift and any variations in temperature at different points in the chamber. However, in order to maintain the relative humidity throughout the chamber within the required tolerances, it is necessary to keep the temperature difference between any two points in the chamber at any given time within narrower limits. Specimens being exposed in the chamber shall not be subjected to radiant heat from the chamber temperature-control devices.

The chamber temperature shall be measured at least 100 mm from the walls.

4.2 Exposure conditions

4.2.1 Damp heat

4.2.1.1 General

The preferred exposure conditions correspond to those described in the IEC publications referred to in 4.2.1.2 and 4.2.1.3. Different temperature and/or humidity conditions may be used, however, if specified in the relevant product specifications or by agreement between the interested parties.

4.2.1.2 Steady state test

Unless otherwise specified, the chamber shall be at ambient laboratory temperature and humidity at the start of the test. Place the conditioned specimens (see 4.3.1) in the chamber and adjust the controls to produce the following conditions:

temperature: 40^{+2}_{-1} °C;

relative humidity: 93^{+4}_{-8} %.

As the chamber temperature is increasing to 40 °C, the rate of temperature change shall not exceed 1 °C/min, averaged over a period of not more than 5 min. During the heating-up period, condensation shall not occur on the specimens.

Once the specified temperature is reached, adjust the relative humidity to the specified level within no more than 2 h.

The period of exposure shall be as specified by the specification covering the material or product being tested. When not specified, this period shall be agreed upon by the interested parties. Recommended periods of exposure are 12 h, 16 h, 24 h, 48 h, 96 h and 240 h.

NOTE The conditions given in this subclause correspond to those specified in IEC 60068-2-78:2001.

4.2.1.3 Cyclic test

This test takes the chamber and specimens through a number of 24 h cycles during which the temperature shall be maintained at an upper value and at (25 ± 3) °C. One of the following two temperatures shall be chosen as the upper temperature:

- a) (40 ± 1) °C (in which case the number of cycles shall be 2, 6, 12, 21 or 56);
- b) (55 ± 1) °C (in which case the number of cycles shall be 1, 2 or 6).

The upper temperature shall be reached within the first $3\text{ h} \pm 30\text{ min}$ of each 24 h cycle. During this temperature increase, the relative humidity shall not drop below 95 %, except during the last 15 min when the relative humidity may drop below 95 % but not below 90 %. During the temperature increase, condensation on the specimens is allowed.

In the following hours, the temperature shall be maintained at the upper value chosen and the relative humidity shall be maintained at (93 ± 4) %.

After 12 h of the 24 h cycle, the temperature shall be allowed to decrease, within 3 h to 6 h, to the lower temperature of (25 ± 3) °C. During this temperature decrease, the relative humidity shall not drop below 80 %.

For the rest of the 24 h cycle, the temperature shall be maintained at (25 ± 3) °C and the relative humidity shall not be less than 95 %.

NOTE 1 The conditions given in this subclause correspond to those specified in IEC 60068-2-30:2005 (using variant 2 for the temperature decrease part of the cycle).

NOTE 2 For composite temperature/humidity cycles, with the addition of a number of excursions to sub-zero temperatures, guidance can be found in IEC 60068-2-38.

4.2.2 Water spray

The main difference between this exposure condition and that for damp heat/steady state (see 4.2.1.2) is the constant presence of the liquid phase, in the form of small water droplets.

Suitable equipment for obtaining these conditions is substantially identical to that for the salt mist exposure (see 4.2.3) and is described in the relevant specifications.

Distilled or deionized water, having a pH between 6 and 7, shall be used instead of the salt solution.

The temperature in the test enclosure shall be $(40 \pm 2) ^\circ\text{C}$.

4.2.3 Salt mist

Dissolve a sufficient mass of sodium chloride in distilled or deionized water with a conductivity not higher than $20 \mu\text{S}/\text{cm}$ at $(25 \pm 2) ^\circ\text{C}$ to produce a concentration of $(50 \pm 5) \text{ g/l}$. The specific-gravity range for a $(50 \pm 5) \text{ g/l}$ solution is 1,029 to 1,036 at $25 ^\circ\text{C}$.

The sodium chloride shall contain less than 0,001 % by mass of copper and less than 0,001 % by mass of nickel, as determined by atomic absorption spectrophotometry or another analytical method of similar sensitivity. It shall not contain more than 0,1 % by mass of sodium iodide or more than 0,5 % by mass of total impurities, calculated with respect to the dry salt.

Adjust the pH of the salt solution so that the pH of the salt mist collected in the chamber (see below) is between 6,5 and 7,2 at $(25 \pm 2) ^\circ\text{C}$. Check the pH by electrometric measurement or, for routine checks, using short-range pH paper which can be read in increments of 0,3 pH-units or less. Make any necessary correction by adding hydrochloric acid, sodium hydroxide or sodium bicarbonate solution prepared from analytical-grade reagents.

The temperature inside the cabinet shall be $(35 \pm 2) ^\circ\text{C}$.

The chamber shall contain at least two devices for collecting salt mist. These devices shall include a horizontal surface of area 80 cm^2 on which mist will be deposited during the exposure. They shall be placed so that only mist, and not liquid falling from specimens or from parts of the cabinet, is collected. They shall be used to ensure that the following requirements are met:

- the average collection rate shall be 1 ml/h to 2 ml/h when measured over a period of at least 16 h;
- the pH of the mist collected shall be between 6,5 and 7,2 at $(25 \pm 2) ^\circ\text{C}$ (see above);
- the sodium chloride concentration in the mist collected shall be $(50 \pm 5) \text{ g/l}$.

NOTE 1 The conditions given in this subclause correspond to those specified in ISO 9227:2006 and IEC 60068-2-11:1981.

NOTE 2 In this test, the exposure temperature used is $35 ^\circ\text{C}$, even though this temperature is not included among those recommended in ISO 3205, because it is specified in ISO 9227 and in the majority of existing national standards.

The period of exposure shall be as specified by the specification covering the material or product being tested. When not specified, this period shall be agreed upon by the interested parties. Recommended periods of exposure are 2 h, 6 h, 24 h, 48 h, 96 h, 168 h, 240 h, 480 h, 720 h and 1 000 h.

4.3 Test specimens (see 5.2, 6.2 and 7.2)

4.3.1 Conditioning

Unless otherwise agreed by the interested parties, the test specimens shall be conditioned before testing for at least 86 h at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 10) \% \text{RH}$.

For certain materials which are known to approach rapidly, or on the contrary very slowly, the state of equilibrium of temperature and, above all, of humidity, shorter or longer conditioning periods may be specified in the particular specifications concerning them (see Annex A).

4.3.2 Treatment after exposure

4.3.2.1 General

The exposed specimens shall be tested either

- a) directly after the exposure, or
- b) after the exposure and subsequent drying or reconditioning.

The first procedure shall be used when it is required to know the state of the material while it still contains the amount of water it had absorbed by the end of the exposure. The second procedure shall be used when it is required to determine the changes in properties of the material as a result of the exposure only. In the case of reconditioning, the specimens shall be brought back, as far as possible, to the same state as the initial state before exposure with regard to equilibrium with atmospheric humidity (see 4.3.1).

4.3.2.2 Test after exposure only

After rinsing with distilled or deionized water, if necessary, and wiping dry, the exposed specimens shall be brought to $(23 \pm 2) ^\circ\text{C}$ in a closed container; usually 4 h are sufficient for this purpose.

4.3.2.3 Test after exposure and drying or reconditioning

After rinsing and wiping dry, the specimens shall be dried or reconditioned to equilibrium with the same atmospheric conditions as before the exposure (see 4.3.1), taking due account of the procedures described in A.3.1 and A.3.2 in Annex A. Unless otherwise specified in the relevant product standard or agreed upon between the interested parties, the specimens shall be dried in an oven at $(50 \pm 2) ^\circ\text{C}$ for 24 h and cooled to $(23 \pm 2) ^\circ\text{C}$ in a desiccator.

Specimens more than 200 μm thick will not be in humidity equilibrium after 24 h (see ISO 62). Therefore, a longer drying time is recommended for such specimens. If a longer drying time is used, it shall be agreed upon by all interested parties and stated in the test report.

5 Change of mass

5.1 General

5.1.1 In this type of test, the changes in mass are at least partially due to water absorption, and they are therefore particularly influenced by the conditioning and drying/reconditioning of the test specimens.

It is important, therefore, that the precise conditions of test be specified in the relevant product specifications.

Normally, the specimens are weighed immediately after exposure, rinsing and wiping dry, or are treated as described in 4.3.2.2.

If the determination of mass after drying or reconditioning is required, the specimens shall be dried or reconditioned as specified in 4.3.2.3.

NOTE This test is not applicable to cellular materials.

5.1.2 The changes of mass are generally proportional to the surface area of the test specimens, but are influenced by their thickness.

IMPORTANT — It is emphasized that the comparison of different plastics by means of this test is valid only if the test specimens used are of the same shape, the same dimensions and in as nearly as possible the same state (of surface, internal stresses, etc.).

5.2 Test specimens

5.2.1 General

The test specimens may be obtained directly by moulding or by machining. In the latter case, the cut surfaces shall be smooth and shall not show any trace of charring that may be due to the method of preparation.

5.2.2 Moulding and extrusion compounds

The test specimens shall be in the form of a square of (50 ± 1) mm side and $(3,0 \pm 0,2)$ mm thick. Rectangular specimens having the same surface area (for example $100 \text{ mm} \times 25 \text{ mm}$, i.e. $2\,500 \text{ mm}^2$) may be used.

The specimens may be cut from a sheet of the same thickness, or prepared by compression or injection moulding or by extrusion under the conditions given in the relevant specification for the material or under the conditions prescribed by the supplier of the material.

Moulding materials may be, alternatively, directly moulded in a mould of the prescribed dimensions.

NOTE The general principles for preparing moulded and machined test specimens are the subject of the following International Standards: ISO 293, ISO 294-1, ISO 294-2, ISO 294-3, ISO 295, ISO 2818.

5.2.3 Sheet

The specimens shall be (50 ± 1) mm square or rectangular, having the same surface area, and shall be cut from the sheet under test.

If the nominal thickness of the sheet under test is equal to or less than 25 mm, the thickness of the test specimen shall be the same as that of the sheet.

If the nominal thickness is greater than 25 mm and in the absence of special provisions in the relevant specification, the thickness of the test specimen shall be reduced to 25 mm by machining on one surface only.

The machined surface shall not be directly exposed to water or salt spray.

A complete description of the machining, if any, shall be included in the test report.

5.2.4 Semi-finished and finished products (other than sheets)

The specimens shall be as similar in shape and size as possible to the specimens described in 5.2.2, and be prepared in accordance with the product specification or as agreed upon between the interested parties.

If any machining is necessary, a complete description thereof shall be included in the test report.

5.2.5 Number of test specimens

At least three specimens shall be tested.

5.3 Conditioning

See 4.3.1.

5.4 Procedure

5.4.1 Determine the mass (m_1) of each specimen to the nearest 0,001 g.

5.4.2 Expose the specimens to the test environment chosen from those listed in Clause 4.

5.4.3 Rinse, if necessary (for example in the case of exposure to salt mist), and wipe the specimens dry.

5.4.4 Immediately determine the mass (m_2) of each specimen to the nearest 0,001 g.

5.4.5 Dry or recondition the specimens, if required, in accordance with 4.3.2.3 and determine the mass (m_3) of each specimen to the nearest 0,001 g.

5.5 Expression of results

5.5.1 The change of mass per unit area, in grams per square metre, is given by the formula

$$\frac{m_2 - m_1}{S} \text{ or } \frac{m_3 - m_1}{S}, \text{ respectively,}$$

where

m_1 , m_2 and m_3 are as defined in 5.4.1, 5.4.4 and 5.4.5;

S is the initial total surface area (including the edges of the specimens) in square metres.

5.5.2 The change of mass, as a percentage, is given by the formula

$$\frac{m_2 - m_1}{m_1} \times 100 \text{ or } \frac{m_3 - m_1}{m_1} \times 100, \text{ respectively.}$$

The change is positive for increase of mass and negative for reduction of mass.

5.5.3 Calculate the mean value of the test results for all the specimens from a given sample.

6 Change of dimensions and appearance

6.1 General

Change of dimensions may result from either volume changes due to water absorption or leaching of some components, or to relaxation of internal moulded-in stresses, or both.

It is important, therefore, that the precise conditions of test be specified in the relevant product specifications.

For anisotropic materials, such as calendered or extruded sheets or extruded rods, the changes in linear dimensions in the machine direction (lengthwise) and in the transverse direction (crosswise) may be different; it is therefore necessary to determine the changes in both directions.

Where it is desired to differentiate between the effect of the relaxation of moulded-in stresses and that of the action of water, the test may also be performed using a set of annealed specimens.

6.2 Test specimens

Prepare the test specimens as described in 5.2. For anisotropic materials, the sides shall be parallel to the machine and transverse directions, respectively (see 6.1).

The dimensional measurements may be made on the same specimens as were used for the determination of the changes in mass, immediately after weighing them.

6.3 Conditioning

See 4.3.1.

6.4 Procedure

6.4.1 Measure the thickness of each specimen at four marked points to an accuracy of 0,01 mm using a dial micrometer, and calculate the mean value (\bar{d}_1).

Measure individually the four sides of the square or the rectangle to an accuracy of 0,1 mm and calculate the mean values of the dimensions in the two perpendicular directions, respectively (length \bar{l}_1 and width \bar{b}_1). For less regularly shaped specimens, for example from semi-finished or finished products, measure the most meaningful dimensions.

6.4.2 Expose the specimens to the test environment chosen from those listed in Clause 4.

6.4.3 Rinse, if necessary (for example in the case of exposure to salt mist), and wipe the specimens dry.

6.4.4 Remeasure the specimens in the same manner as before exposure, i.e. determine the dimensions after exposure (\bar{l}_2 , \bar{b}_2 and \bar{d}_2).

If the specimens have undergone severe warpage, the linear measurements should be carried out with a tape measure.

6.4.5 Note any change in appearance.

6.4.6 Dry or recondition the specimens, if required, as described in 4.3.2.3 and determine the dimensions after drying or reconditioning (\bar{l}_3 , \bar{b}_3 , \bar{d}_3).

6.5 Expression of results

The results may be expressed in either of two ways:

- a) as the percentage change in dimension (after exposure), based on the initial dimension, using, as applicable, the formulae

$$\frac{\bar{l}_2 - \bar{l}_1}{\bar{l}_1} \times 100, \quad \frac{\bar{b}_2 - \bar{b}_1}{\bar{b}_1} \times 100, \quad \frac{\bar{d}_2 - \bar{d}_1}{\bar{d}_1} \times 100$$

or (after exposure and drying or reconditioning)

$$\frac{\bar{l}_3 - \bar{l}_1}{\bar{l}_1} \times 100, \quad \frac{\bar{b}_3 - \bar{b}_1}{\bar{b}_1} \times 100, \quad \frac{\bar{d}_3 - \bar{d}_1}{\bar{d}_1} \times 100$$

The change is positive for increase and negative for decrease in the dimension.

- b) as the percentage of the final dimension relative to the initial dimension, using, as applicable, the formulae

$$\frac{\bar{l}_2}{\bar{l}_1} \times 100, \quad \frac{\bar{b}_2}{\bar{b}_1} \times 100, \quad \frac{\bar{d}_2}{\bar{d}_1} \times 100$$

or

$$\frac{\bar{l}_3}{\bar{l}_1} \times 100, \quad \frac{\bar{b}_3}{\bar{b}_1} \times 100, \quad \frac{\bar{d}_3}{\bar{d}_1} \times 100, \text{ respectively.}$$

In this case, 100 % means no change, values lower than 100 % mean a reduction and values higher than 100 % mean an increase in the dimensions.

Report any apparent deformation such as warpage, curling, delamination, or visible signs of surface degradation such as:

- change in colour and/or gloss, presence of crazing, cracks;
- blisters;
- exudation of plasticizers, tackiness;
- blooming of solid ingredients;
- corrosion of metal components, if any;

and assign, if possible, a qualification such as slight, moderate, severe, etc.

7 Change of other physical properties

7.1 General

Any physical property may be determined; the most significant are usually the mechanical, optical and electrical properties.

It is important that the precise conditions of test be specified in the relevant product specifications.

7.2 Test specimens

The size, shape and number of test specimens shall be as specified in the International Standard for the determination of the relevant property.

If the test is a destructive one, the number of test specimens shall be doubled.

Samples may be in the form of a sheet from which the specimens for the particular test are cut. Since the results obtained on specimens prepared before the exposure might be different from those obtained on specimens cut out after the exposure, owing to the action of the exposure on the cut edges, the procedure of preparation of the specimens shall be precisely stated in the test report.

7.3 Conditioning

See 4.3.1.

7.4 Procedure

- 7.4.1** Determine the value (P_1) of each of the intended properties, using a set of test specimens.
- 7.4.2** Expose a second set of specimens to the test environment chosen from those listed in Clause 4.
- 7.4.3** Rinse and wipe dry.
- 7.4.4** Determine the value (P_2) of each of the properties after exposure.
- 7.4.5** If required, expose a third set of specimens, rinse, wipe and dry or recondition in accordance with 4.3.2.3; determine the value (P_3) of each of the properties after exposure and drying or reconditioning to the same moisture equilibrium state as that of the specimens used to determine P_1 .

7.5 Expression of results

The results may be expressed in either of two ways:

- a) as the percentage change of property, using the formula

$$\frac{P_2 - P_1}{P_1} \times 100 \text{ or } \frac{P_3 - P_1}{P_1} \times 100, \text{ respectively;}$$

- b) as the percentage of the final property, relative to the initial one, using the formula

$$\frac{P_2}{P_1} \times 100 \text{ or } \frac{P_3}{P_1} \times 100, \text{ respectively.}$$

8 Test report

The test report shall include the following particulars:

- a) a reference to this International Standard;
- b) all details necessary for complete identification of the material or product;
- c) the type of exposure used;
- d) the treatment of the specimens before and after the exposure;
- e) the properties examined;
- f) details of the preparation of the specimens, with particular mention of any machining;
- g) the type of specimen tested;
- h) the values of the properties before and after exposure;
- i) the corresponding changes, calculated in accordance with 5.5, 6.5 and 7.5, as appropriate, including the signs;
- j) if available, curves of properties as a function of time of exposure;
- k) any observations of changes in appearance of the exposed specimens;
- l) the date(s) of testing.

Annex A (informative)

Absorption of moisture by a test specimen of a plastics material in equilibrium with its conditioning atmosphere

A.1 The amount and rate of absorption of moisture by a test specimen conditioned in a humid atmosphere varies significantly according to the nature of the plastics material tested (see ISO 62).

A.2 The normal conditions for conditioning established in this International Standard (see 4.3.1) are generally satisfactory, except for the following:

A.2.1 Materials known to reach equilibrium with their conditioning atmosphere only after a very long period of time (for example, certain polyamides).

A.2.2 New materials or those of unknown structure, for which no *a priori* forecast can be made either of their capacity for absorbing moisture or of the time required for reaching equilibrium.

A.3 In these two cases, one of two procedures can be followed:

A.3.1 Drying the material at elevated temperature. This procedure has the disadvantage that certain properties, mechanical in particular, in the dry state differ from those obtained after conditioning at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 10) \% \text{RH}$.

A.3.2 Conditioning the test specimen at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 10) \% \text{RH}$ until equilibrium is achieved. In this case, a suitable criterion could be one of the following:

- a) Mass constant within 0,1 % for two determinations separated by an interval of d^2 weeks (d being the thickness of the test specimen in millimetres).
- b) For certain polymers, it is sufficient to plot the graph of mass against time, with intervals much less than d^2 weeks, equilibrium being considered achieved for practical purposes when the gradient of the curve, expressed as a percentage, is equal to 0,1 %.

Bibliography

- [1] ISO 175, *Plastics — Methods of test for the determination of the effects of immersion in liquid chemicals*
- [2] ISO 293, *Plastics — Compression moulding of test specimens of thermoplastic materials*
- [3] ISO 294-1, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 1: General principles, and moulding of multipurpose and bar test specimens*
- [4] ISO 294-2, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 2: Small tensile bars*
- [5] ISO 294-3, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 3: Small plates*
- [6] ISO 295, *Plastics — Compression moulding of test specimens of thermosetting materials*
- [7] ISO 2818, *Plastics — Preparation of test specimens by machining*
- [8] ISO 3205, *Preferred test temperatures*
- [9] ISO 4582, *Plastics — Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or laboratory light sources*
- [10] ISO 9142:2003, *Adhesives — Guide to the selection of standard laboratory ageing conditions for testing bonded joints*
- [11] ISO 9227:2006, *Corrosion tests in artificial atmospheres — Salt spray tests*
- [12] IEC 60068-2-11:1981, *Environmental testing — Part 2: Tests. Test Ka: Salt mist*
- [13] IEC 60068-2-30:2005, *Environmental testing — Part 2-30: Tests — Test Db: Damp heat, cyclic (12 h + 12 h cycle)*
- [14] IEC 60068-2-38, *Environmental testing — Part 2-38: Tests — Test Z/AD: Composite temperature/humidity cyclic test*
- [15] IEC 60068-2-78:2001, *Environmental testing — Part 2-78: Tests — Test Cab: Damp heat, steady state*

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards-based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

All the data, software and documentation set out in all British Standards and other BSI publications are the property of and copyrighted by BSI, or some person or entity that owns copyright in the information used (such as the international standardization bodies) and has formally licensed such information to BSI for commercial publication and use. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI. Details and advice can be obtained from the Copyright & Licensing Department.

Useful Contacts:

Customer Services

Tel: +44 845 086 9001

Email (orders): orders@bsigroup.com

Email (enquiries): cservices@bsigroup.com

Subscriptions

Tel: +44 845 086 9001

Email: subscriptions@bsigroup.com

Knowledge Centre

Tel: +44 20 8996 7004

Email: knowledgecentre@bsigroup.com

Copyright & Licensing

Tel: +44 20 8996 7070

Email: copyright@bsigroup.com