
**Plastics — Methods of test for the
determination of the effects of immersion
in liquid chemicals**

*Plastiques — Méthodes d'essai pour la détermination des effets de
l'immersion dans des produits chimiques liquides*

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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.

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

This third edition cancels and replaces the second edition (ISO 175:1999), of which it constitutes a minor revision.

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Introduction

Because of their varied applications, plastics are frequently brought into contact with liquids such as chemical products, motor fuels, lubricants, etc., and, possibly, with their vapours.

Under the action of a liquid, a plastic material may be subjected to several phenomena which may occur simultaneously. On the one hand, absorption of liquid and extraction of constituents soluble in the liquid may occur. On the other hand, a chemical reaction, often resulting in a significant change in the properties of the plastic, may occur. The equilibrium swelling ratio for a crosslinked polymer in a liquid that is a solvent for the same but non-crosslinked polymer is a measure of the degree of crosslinking.

The behaviour of plastics in the presence of liquids can be determined only under arbitrarily fixed conditions aimed at making comparisons between different materials. The choice of test conditions (nature of the liquid, immersion temperature and immersion time), as well as the choice of the properties in which changes are to be measured, depends on the eventual application of the plastic under test.

It is not possible, however, to establish any direct correlation between the experimental results and the behaviour of the plastic in service. These tests do, nevertheless, permit a comparison to be made of the behaviour of different plastic materials under specified conditions, thus allowing an initial evaluation of their behaviour in relation to certain groups of liquids.

NOTE In view of its special importance, the particular case of the determination of the quantity of water absorbed is dealt with in ISO 62. ISO 175 is concerned with the effects of water only where changes in the dimensions and physical properties of the plastic occur as a result of the action of the water.

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Plastics — Methods of test for the determination of the effects of immersion in liquid chemicals

1 Scope

1.1 This International Standard specifies a method of exposing test specimens of plastic materials, free from all external restraint, to liquid chemicals, and methods for determining the changes in properties resulting from such immersion. It does not cover environmental stress cracking (ESC) which is dealt with by the various parts of ISO 22088.

1.2 It only considers testing by immersion of the entire surface of the test specimen¹⁾.

NOTE This method may not be appropriate for simulating partial or infrequent wetting of plastics.

1.3 It is applicable to all solid plastics that are available in the form of moulding or extrusion materials, plates, tubes, rods or sheets having a thickness greater than 0,1 mm. It is not applicable to cellular materials.

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2 Normative references (standards.iteh.ai)

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 291:2008, *Plastics — Standard atmospheres for conditioning and testing*

ISO 294-3, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 3: Small plates*

ISO 2818, *Plastics — Preparation of test specimens by machining*

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 4582, *Plastics — Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or laboratory light sources*

IEC 60296, *Fluids for electrotechnical applications — Unused mineral insulating oils for transformers and switchgear*

1) Although it is not within the scope of this International Standard, it may also be of interest, when dealing with volatile liquids or those which give off vapours, to subject the specimen to only the gaseous phase above the liquid. In this event, it is advisable to proceed exactly as indicated, but to suspend the specimen above the liquid, seal the container and maintain it at the test temperature throughout.

3 Principle

Test specimens are completely immersed in a test liquid for a specified time and at a specified temperature.

Their properties are determined before immersion and after removal from the liquid, as well as after drying, if applicable. In the last-mentioned case, the determinations are made, if possible, one after the other on the same specimens.

NOTE The comparison of different plastics by means of this test is valid only if the specimens used are of the same shape, of the same dimensions (in particular of the same thickness) and in as nearly as possible the same state (of internal stress, surface, etc.).

Methods are specified for determining the following:

- a) changes in mass, dimensions and appearance immediately after removal from the liquid and after removal and drying;
- b) changes in physical properties (mechanical, thermal, optical, etc.) immediately after removal from the liquid and after removal and drying;
- c) the amount of liquid absorbed.

Measurements are made immediately after removal when it is necessary to ascertain the state of the material while it is still being acted on by the liquid. Measurements are made after removal and drying when it is necessary to ascertain the state of the material after the liquid, provided it is volatile, has been eliminated. It also allows the influence of a soluble constituent to be determined.

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4 General requirements and procedure

4.1 Test liquids

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4.1.1 Choice of test liquid

If information is required about the behaviour of a plastic in contact with a specific liquid, that liquid shall be used. The test liquid shall be of analytical quality.

Industrial liquid chemicals are not generally of absolutely constant composition. The tests shall be carried out using defined chemical products, either on their own or as a mixture, which are as representative as possible of the products under consideration in their effect on the plastic material concerned. When technical-grade chemicals are used, they shall be of agreed origin and quality, and care shall be taken that only one manufacturing batch is used for all measurements in any one series.

If conducting a series of tests in a liquid of doubtful composition, it is important to take all the samples of the liquid from the same container.

4.1.2 Types of test liquid

Types of test liquid are given in Annex A.

4.2 Test conditions

4.2.1 Test temperatures

The preferred test temperatures are:

- a) $(23 \pm 2) ^\circ\text{C}$;
- b) $(70 \pm 2) ^\circ\text{C}$.

If a different temperature has to be used in order to correspond to the temperature at which the plastic is to be used, it shall be selected from one of the following temperatures:

−269 °C; −196 °C; −161 °C; −70 °C; −55 °C; −40 °C; −25 °C; −10 °C; 0 °C; 5 °C; 25 °C; 40 °C; 55 °C; 70 °C; 85 °C; 100 °C; 105 °C; 125 °C; 150 °C; 175 °C; 200 °C; 225 °C; 250 °C; 275 °C; 300 °C; 350 °C; 400 °C; 450 °C; 500 °C; 600 °C; 700 °C; 800 °C; 900 °C; 1 000 °C

NOTE These temperatures originate from ISO 3205:1976.

The following temperatures are recommended:

0 °C; 20 °C; 27 °C; 40 °C; 55 °C; 85 °C; 95 °C; 100 °C; 125 °C; 150 °C

with a tolerance of ± 2 °C on temperatures up to and including 100 °C and ± 3 °C on temperatures greater than 105 °C up to and including 200 °C. In the special case of testing plastic pipes, the temperature of 60 °C given in the annex to ISO 3205:1976 may be used.

In the event that the test is to be carried out at a temperature above normal ambient conditions, it may be desirable to condition another series of specimens at this temperature for a period equal to that of the test, and to measure their properties after this conditioning in order to be able to distinguish the effect of temperature from that of the liquid.

In the case of long-duration tests, specimens stored in air at 23 °C may undergo a change in properties. Preparation of an additional series of test specimens is recommended for comparison purposes.

4.2.2 Measurement temperature

The temperature for the determination of changes in mass, dimensions or physical properties is $23 \text{ °C} \pm 2 \text{ °C}$. If the immersion temperature is different, bring the specimen to 23 °C by the procedure described in 4.6.3.

4.3 Immersion time

The preferred immersion times are:

- a) 24 h for a short-duration test;
- b) 1 week for a standard test (particularly at 23 °C);
- c) 16 weeks for a long-duration test.

If other immersion times need to be used, for example if it is desired to perform tests as a function of time or to plot the curve until equilibrium is reached, it is recommended that the immersion times be chosen from the following standard scale:

- d) 1 h — 2 h — 4 h — 8 h — 16 h — 24 h — 48 h — 96 h — 168 h;
- e) 2 weeks — 4 weeks — 8 weeks — 16 weeks — 26 weeks — 52 weeks — 78 weeks;
- f) 1,5 years — 2 years — 3 years — 4 years — 5 years.

4.4 Test specimens

Depending upon the measurements to be made after immersion (mass, dimensions, physical properties) and the nature and form of the plastic material (sheet, film, rod, etc.), the specimens will be of very diverse shapes and dimensions.

They may be obtained directly by moulding, or by machining. In the latter case, cut surfaces shall be machined to a fine finish and shall show no trace of carbonization that could be attributed to the method of preparation.

For the specimens specified in 5.3.1 and 5.3.2, the preferred specimen size is 60 mm × 60 mm with a thickness depending on the type of plastic material:

- for thermoplastics, the preferred thickness is 1,0 mm to 1,1 mm;
- for moulding compounds, the specimen is identical to that specified in ISO 294-3;
- for semi-finished materials, the specimen should preferably be prepared by machining in accordance with ISO 2818, leaving at least one original surface intact;
- for composites, the preferred thickness is at least 2 mm.

NOTE Tests using specimens thinner or thicker than the recommended 1 mm can be conducted to determine whether specimen thickness effects changes in mass, dimensions, appearance or amount of liquid absorbed.

The number of specimens to be used will be specified in the International Standards relevant to the tests to be carried out after treatment. In the absence of specific International Standards, at least three specimens shall be tested.

4.5 Conditioning

Condition the specimens in atmosphere 23/50, class 2, as defined in ISO 291:2008.

NOTE For certain plastics which are known to approach temperature equilibrium and, in particular, humidity equilibrium rapidly or very slowly, shorter or longer conditioning periods can be specified in the appropriate product specifications (see Annex B).

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4.6 Procedure

4.6.1 Quantity of test liquid

The quantity of test liquid used shall be at least 8 ml per square centimetre of the total surface area of the specimen in order to avoid too high a concentration of any extracted products in the liquid during the course of the test. The test liquid shall cover the specimen completely.

NOTE A different quantity of liquid might, however, be specified in particular International Standards; for example, for rigid PVC and polyolefin pipes, where the amount of extractable substances is known to be very small, a smaller quantity of liquid is specified in the relevant International Standards.

4.6.2 Positioning of specimens

Place each set of test specimens in a suitable container (see 5.2) and completely immerse them in the test liquid (using a weight if necessary). When several materials of the same composition are to be tested, it is permissible to put several sets of specimens in the same container.

Ensure that, for every specimen, only an insignificant proportion of the surface of the specimen makes contact with the surfaces of other specimens, with the walls of the container or with any weight that is used.

During the test, stir the liquid, for example by swirling it in the container, at least once per day.

If the test lasts longer than seven days, replace the liquid with an equal amount of the original liquid every seventh day (see Note 2 to 4.6.3).

If the liquid is unstable (for example in the case of sodium hypochlorite), replace the liquid more frequently.

If light is likely to affect the action of the test liquid, it is recommended that the test be carried out either in darkness or under defined illumination conditions.

It may be necessary in certain cases to specify the height of the liquid level above the specimens (for example if there is a risk of oxidation) or to measure the volume of the liquid absorbed. The volume absorbed by the specimen is the difference between the initial volume of the liquid and the volume of the remaining liquid. Where it is necessary to calculate this, the apparatus shall allow the measurement of the volume of the liquid alone.

4.6.3 Rinsing and wiping

At the end of the period of immersion, bring the temperature of the specimens back to ambient temperature if necessary by transferring them quickly into a fresh quantity of test liquid at room temperature and leaving them for a period of 15 min to 30 min.

Use one of the following procedures for rinsing the specimens after they have been removed from the test liquid:

- a) For specimens which have been immersed in acid, alkali or other aqueous solutions, rinse thoroughly with clean water. Hygroscopic reagents such as concentrated sulfuric acid may remain adsorbed on the surface of the specimens even after rinsing, requiring immediate special treatment to avoid moisture pickup before and during weighing.
- b) For specimens removed from non-volatile, non-water-soluble organic liquids, rinse with a non-aggressive but volatile solvent such as light naphtha.

NOTE 1 In the case of specimens immersed in volatile liquids such as acetone or alcohol at ambient temperature, rinsing and wiping may not be necessary.

Wipe the specimens dry with filter paper or a lint-free cloth.

NOTE 2 It may be necessary to examine the test liquid at the end of the test. This examination could be a simple visual examination, a measurement of the volume or mass of the liquid not absorbed, or a more rigorous examination, including, for example, a titration.

This examination may not be meaningful if the liquid has been replaced during the test.

4.7 Expression of results

4.7.1 Numerical expression

In addition to giving the measurements made before and after immersion, the value of the property after immersion (X_2) may be expressed (except in special cases of changes in mass) as a percentage of the value before immersion (X_1), using the following formula:

$$\frac{X_2}{X_1} \times 100$$

4.7.2 Graphical expression

In every case where measurements are made as a function of time, it is recommended that graphs be plotted. Plot the values obtained (including the original value), or the differences in value, as the ordinates and the immersion times t as the abscissae. If it is necessary to shorten the immersion-time scale, either a $t^{0.5}$ scale or a $\log t$ scale may be used.

The double-logarithmic plot as recommended in ISO 62 of, for example, the mass or volume of liquid absorbed versus the immersion time allows the determination of the concentration at saturation and the diffusion coefficient over short immersion times if the absorption follows Fick's laws.