INTERNATIONAL STANDARD

ISO 22088-5

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Plastics — Determination of resistance to environmental stress cracking (ESC) —

Part 5: Constant tensile deformation method

Plastiques — Détermination de la fissuration sous contrainte dans un environnement donné (ESC) —

Partie 5: Méthode de déformation en traction constante

Reference number
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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 22088-5 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

ISO 22088 consists of the following parts, under the general title *Plastics — Determination of resistance to environmental stress cracking (ESC)*:

— *Part 1: General guidance*

— *Part 2: Constant tensile load method* (replacement of ISO 6252:1992)

— *Part 3: Bent strip method* (replacement of ISO 4599:1986)

— *Part 4: Ball or pin impression method* (replacement of ISO 4600:1992)

— *Part 5: Constant tensile deformation method* (new test method)

— *Part 6: Slow strain rate method* (new test method)

Plastics — Determination of resistance to environmental stress cracking (ESC) —

Part 5: Constant tensile deformation method

1 Scope

This part of ISO 22088 specifies a method for the determination of the environmental stress cracking (ESC) behaviour of thermoplastics when they are subjected to a constant tensile deformation in the presence of a chemical medium.

It is applicable to test specimens prepared by moulding and/or machining and can be used for the assessment of the ESC behaviour of plastic materials exposed to different environments, as well as for the determination of the ESC behaviour of different plastic materials exposed to a specific environment.

This is essentially a ranking test and is not intended to provide data to be used for design or performance prediction.

NOTE Alternative methods for the determination of environmental stress cracking by means of a constant-strain test are specified in ISO 22088-3 and ISO 22088-4. A method for the determination of environmental stress cracking by means of a constant tensile load is specified in ISO 22088-2.

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 293, *Plastics — Compression moulding of test specimens of thermoplastic materials*

ISO 294-1, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 1: General principles, and moulding of multipurpose and bar test specimens*

ISO 294-5, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 5: Preparation of standard specimens for investigating anisotropy*

ISO 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

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

ISO 22088-1:2006, *Plastics — Determination of resistance to environmental stress cracking (ESC) — Part 1: General guidance*

3 Terms and definitions

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

3.1
stress relaxation
time-dependent decrease in stress

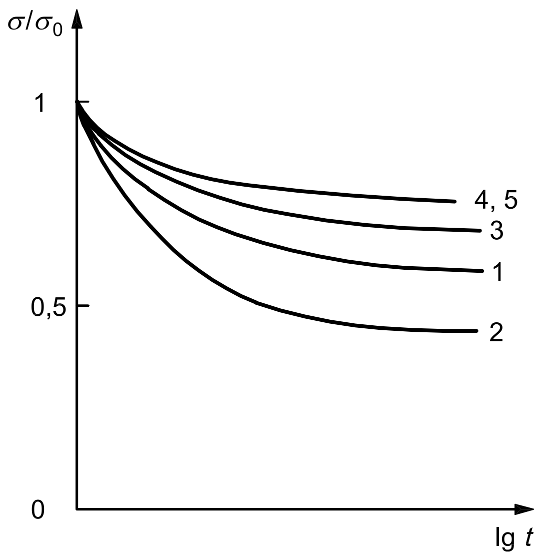
3.2
initial stress
stress occurring when a specimen is first subjected to a constant strain

3.3
stress ratio
ratio of the initial stress to the stress after a certain amount of time

3.4
stress relaxation curve
curve obtained by plotting the stress ratio as ordinate and the logarithm of time as abscissa

3.5
critical stress
maximum stress that can be applied without altering the stress relaxation curve

NOTE The shape of a stress relaxation curve depends upon the strain applied (see Figure 1). Below a certain strain, further reduction of the strain does not change the curve. The stress at this particular strain is defined as the critical stress.



Key

t time

σ_0 initial stress

σ stress at time t

σ/σ_0 stress ratio

NOTE 1 The numbers 1 to 5 indicate the order in which the tests were performed.

NOTE 2 The strains applied to the specimens were as follows: curve 2 > curve 1 > curve 3 > curve 4 > curve 5.

NOTE 3 The stress applied in curve 4 corresponds to the critical stress.

Figure 1 — Determination of critical stress

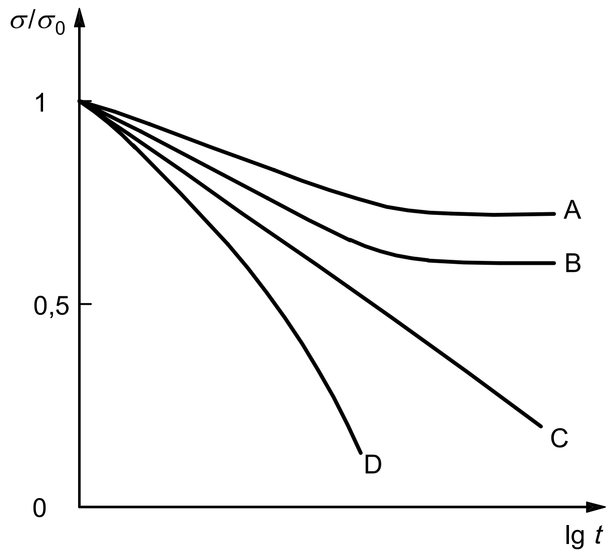
4 Principle

A specimen held at a constant deformation is exposed to a chosen chemical environment at a selected test temperature. The deformation is produced by an initial tensile force that is lower than that at the yield point (or that at the breaking point if the material does not exhibit a yield point) and is held in place by a device such as a worm-gear.

The environmental stress cracking behaviour of the test specimen is evaluated by comparing the critical stress in a selected chemical environment with the critical stress for the same material in air. Comparing the shape of the stress relaxation curve obtained after an initial stress is applied in a selected chemical environment with that of the stress relaxation curve obtained when the same initial stress is applied in air is also an essential part of the evaluation.

The critical stress may be used as an index for ESC. For example, if the critical stress obtained in a particular chemical environment is less than that in air, the material is regarded as being affected by the chemical environment. In addition, it is possible to determine quantitatively the degree of ESC as the difference between the critical stress in air and that in the chemical environment.

The shape of the stress relaxation curve may also be used as a qualitative index of ESC. In Figure 2, curve A is the reference curve in air. Curve B deviates downwards from curve A due to a slight swelling effect caused by the chemical used for this test. Plastics in this state may be safely used when exposed to this chemical if the maximum allowed stress is relatively low. Curve C shows how the molecular structure of a polymer can be weakened by continuous ESC. Curve D indicates how the stress can be reduced very significantly by ESC. Plastics which give curves like C and D are not suitable for use in the chemical environment concerned.



Key

t time

σ_0 initial stress

σ stress at time t

σ/σ_0 stress ratio

Figure 2 — Classification of stress relaxation curves

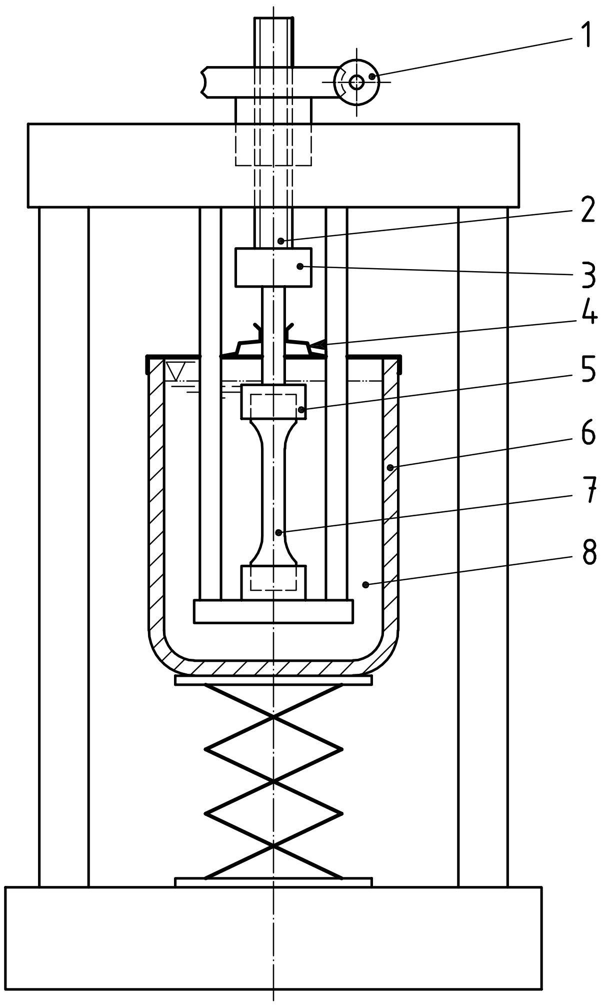
5 Apparatus

5.1 Test device, allowing test specimens to be held at a constant tensile deformation while exposed to a chemical medium (Figure 3 is a schematic diagram of a suitable apparatus).

A strain gauge with an accuracy of ± 1% can be used to measure the tensile load.

The parts of the device which come into contact with the chemical medium shall be made of, or coated with, an inert material, such as stainless steel, polytetrafluoroethylene or another suitable material.

Care shall be taken that the specimens are subjected only to forces parallel to their longitudinal axis, and not to bending or twisting forces.



Key

1 worm-gear
2 screw
3 load cell
4 cover
5 clamp
6 glass container
7 test specimen
8 chemical medium

Figure 3 — One type of apparatus for stress relaxation testing

5.2 Temperature-controlled bath or **oven**, allowing the containers to be maintained at (23 ± 2) °C or at a higher test temperature up to 100 °C to within ± 2 °C (see Clause 6).

5.3 Containers, allowing the test assembly to be immersed completely in a test medium, with a cover that can be sealed for chemicals which are volatile at the immersion temperature. Materials used for containers shall not interact with the immersion liquid.

5.4 Equipment for the preparation of test specimens by moulding (see ISO 293, ISO 294-1 and ISO 294-5), machining (see ISO 2818) or die cutting.

6 Conditioning and test conditions

6.1 Conditioning

Unless otherwise specified in the relevant material standard or agreed upon between the interested parties, the test specimen shall be conditioned before testing for at least 24 h at (23 ± 2) °C and (50 ± 10) % relative humidity.

6.2 Test temperature

The preferred test temperatures are (23 ± 2) °C and (55 ± 2) °C. If required, other temperatures may be used, preferably selected from the following:

(40 ± 2) °C, (70 ± 2) °C, (85 ± 2) °C, (100 ± 2) °C,

or as agreed upon by the interested parties.

6.3 Test medium

See ISO 22088-1:2006, 7.3

7 Test specimens

7.1 Shape and dimensions

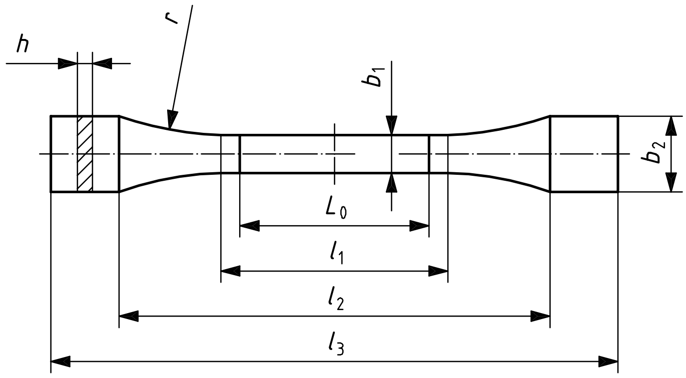
The shape and dimensions of the test specimen shall be as given in Figure 4. This test specimen is the half-size type 1BA test specimen specified in ISO 527-2.

The preferred thickness is (2 ± 0,2) mm, but when the test specimens are prepared from finished products the thickness may be that of the product. Alternatively, a type 1BA specimen 3 mm to 4 mm thick may be used.

7.2 Number

The number of test specimens required for one set of test conditions is 10, i.e. 5 specimens in test medium and in air, respectively.

NOTE If the material is thought to be anisotropic, two sets of specimens shall be used, one set is perpendicular to the principal direction and the other is in the same as the principal direction.



Key

l_3 overall length: 75 mm
b_2 width at ends: (10 ± 0,5) mm
l_1 length of narrow, parallel-sided portion: (30 ± 0,5) mm
b_1 width of narrow, parallel-sided portion: (5 ± 0,5) mm
r radius, minimum: 30 mm
h thickness: preferably (2 ± 0,2) mm
l_0 distance between gauge marks: 25 mm
l_2 initial distance between grips: 57 mm

Figure 4 — ISO 527-2 type 1BA specimen (type 1B scaled down 2:1)

7.3 Preparation

The specimens shall be prepared, taking into consideration the presence or absence of anisotropy, in accordance with the relevant International Standard. If no procedure for specimen preparation is given, specimens shall be machined from sheet or from finished products by the methods specified in ISO 2818.

If sheets are prepared from moulding materials, they shall be moulded in accordance with the relevant material specification or as agreed between the interested parties. Specimens shall not be cut with a die unless machining is impossible, for example with soft materials.

Moulded specimens of isotropic materials shall be prepared in accordance with ISO 293 or ISO 294-1. Moulded specimens of anisotropic materials shall be prepared in accordance with ISO 294-5.

NOTE Environmental stress cracking of a specimen is influenced not only by the material, but also by the method of preparation of the specimen. Materials should only be compared using specimens prepared in a similar manner and in the same state.

8 Test stress

The initial stress applied to the test specimen shall be less than the yield stress of the material at the test temperature (or less than the breaking stress if the material does not exhibit a yield point).

It is recommended that, for a material exhibiting a yield point, approximately half the yield stress be used as the initial stress and that, for a material that does not exhibit a yield point, approximately half the breaking stress be used.

9 Procedure

9.1 Measure, to the nearest 0,01 mm, the thickness and width of the specimen at the centre and at each end of the parallel-sided portion of the specimen and determine the cross-sectional area using the minimum thickness and width from these measurements.

9.2 Calculate the force F, in newtons, to be applied, using the following equation:

$$F = \sigma A$$

where

σ is the stress, in megapascals;

A is the cross-sectional area, in square millimetres.

9.3 Heat the temperature-controlled bath or oven (5.2) to the selected test temperature.

9.4 Insert a specimen in the clamps of the test device (5.1) and immerse it in the test medium.

9.5 After 15 min, apply to the specimen, within 2 min, the force F corresponding to the initial stress chosen, using a device such as a worm-gear by which the deformation produced in the specimen can be kept constant. Record the force until 200 h have elapsed. Plot a first stress relaxation curve, curve 1 (see Figure 1).

9.6 Repeat steps 9.4 and 9.5 with the other test specimens in the set.

9.7 Using a separate set of specimens, conduct the test with a second initial stress slightly higher than the first, and plot a second stress relaxation curve, curve 2. If the second stress relaxation curve is located below the first one, perform the next test with an initial stress lower than the first one. Otherwise, carry out successive tests using initial stresses lower than previous stress until successive stress relaxation curves are superimposed. Record this stress as the critical stress for the test medium used (see 3.5).

9.8 Repeat steps 9.1 to 9.6 in air.

10 Expression of results

Calculate the difference between the critical stress determined in the test medium and that determined in air.

11 Precision

The precision of this method is not known because interlaboratory data are not available in view of the variety of plastics materials and conditions. This method may not be suitable for use in the event of disputed results as long as no precision data are available.

12 Test report

The test report shall include the following particulars:

a) a reference to this part of ISO 22088;

b) all details necessary to identify the material tested;

c) the test medium used;

d) the test temperature;

e) the state of the specimens;

f) the specimen dimensions;

g) the method used to prepare the specimens;

h) the critical stress in the test medium and in air, and the difference between them;

i) the plots of the stress relaxation curves used to determine the critical stress in the test medium and that in air;

j) any operational details not specified in this part of ISO 22088, and any circumstance liable to have influenced the results;

k) the date of testing.

Bibliography

[1] ISO 22088-2, *Plastics — Determination of resistance to environmental stress cracking (ESC) — Part 2: Constant tensile load method*

[2] ISO 22088-3, *Plastics — Determination of resistance to environmental stress cracking (ESC) — Part 3: Bent strip method*

[3] ISO 22088-4, *Plastics — Determination of resistance to environmental stress cracking (ESC) — Part 4: Ball or pin impression method*

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