
**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*

ISO 22088-5:2006

<https://standards.iteh.ai/catalog/standards/sist/5155d07d-dc27-4a97-bdc6-435526fee271/iso-22088-5-2006>



Reference number
ISO 22088-5:2006(E)

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Published in Switzerland

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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.

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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

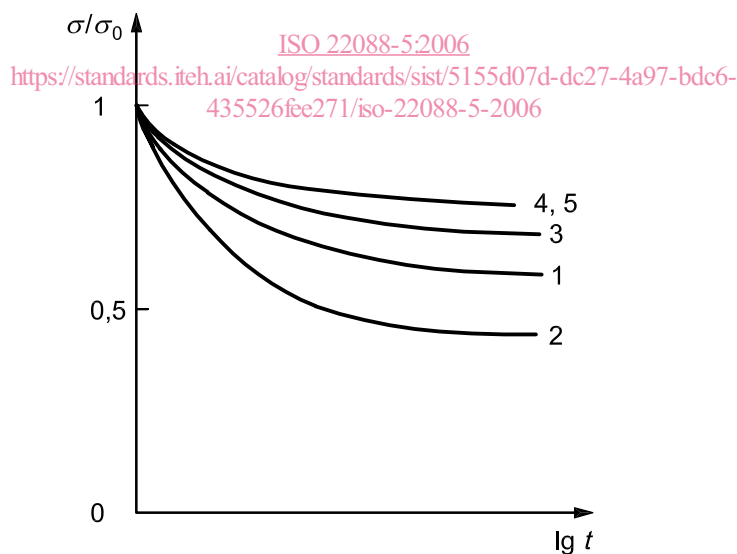
curve obtained by plotting the stress ratio as ordinate and the logarithm of time as abscissa

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.

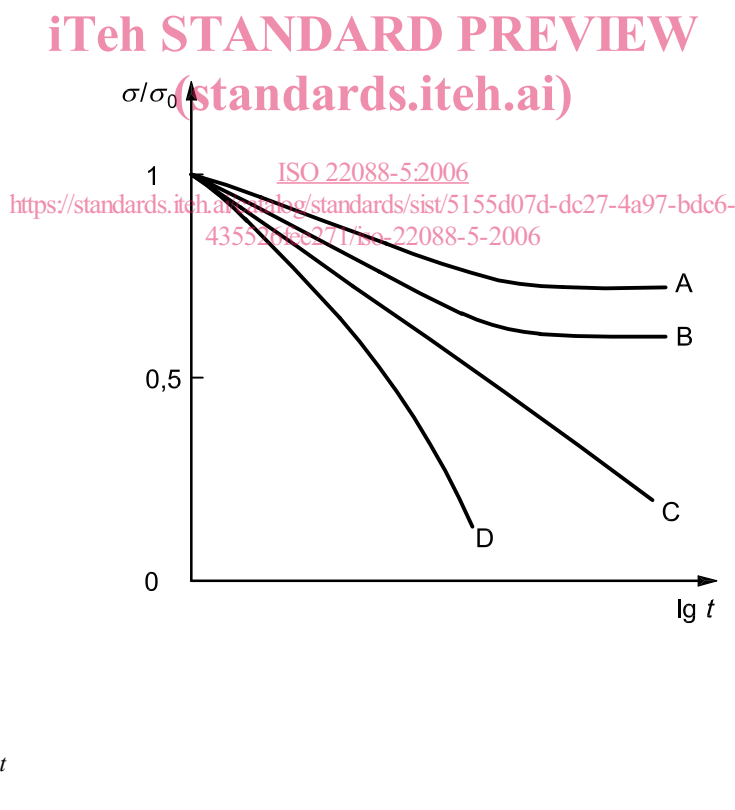


Figure 2 — Classification of stress relaxation curves

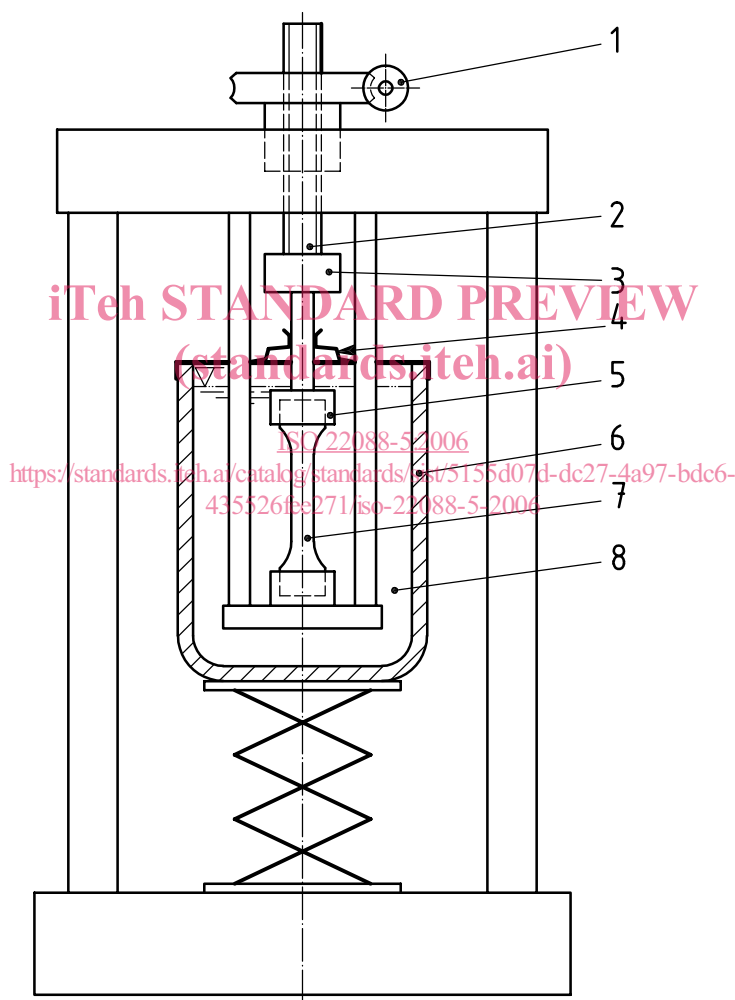
5 Apparatus

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 $\pm 1\%$ 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 | 5 | clamp |
| 2 | screw | 6 | glass container |
| 3 | load cell | 7 | test specimen |
| 4 | cover | 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 $(23 \pm 2) ^\circ\text{C}$ or at a higher test temperature up to $100 ^\circ\text{C}$ to within $\pm 2 ^\circ\text{C}$ (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 $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 10) \%$ relative humidity.

6.2 Test temperature

The preferred test temperatures are $(23 \pm 2) ^\circ\text{C}$ and $(55 \pm 2) ^\circ\text{C}$. If required, other temperatures may be used, preferably selected from the following:

$(40 \pm 2) ^\circ\text{C}$, $(70 \pm 2) ^\circ\text{C}$, $(85 \pm 2) ^\circ\text{C}$, $(100 \pm 2) ^\circ\text{C}$.

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 $(2 \pm 0,2) \text{ mm}$, 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.