INTERNATIONAL STANDARD

ISO 22088-4

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

Part 4:
Ball or pin impression method

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

Partie 4: Méthode par enfoncement de billes ou de goupilles

Reference number
ISO 22088-4:2006(E)

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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.

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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 22088-4 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

It cancels and replaces ISO 4600:1992, which has been technically revised.

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 4: Ball or pin impression method

1 Scope

1.1 This part of ISO 22088 specifies a ball or pin impression method for the determination of the environmental stress cracking (ESC) behaviour of plastics by means of a constant-strain test.

1.2 The method is applicable to finished products and to test specimens prepared by moulding and/or machining, and can be used for the assessment of the ESC behaviour of a plastic product or material exposed to different environments, as well as for the determination of the ESC behaviour of different plastics materials exposed to a specific environment.

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 22088-5. A method for the determination of environmental stress cracking by means of a constant-stress test is specified in ISO 22088-2.

1.3 The ball and pin impression methods are both quick and sensitive procedures for assessing the ESC behaviour of plastics. The methods are well suited for amorphous plastics. They are less appropriate for materials displaying a pronounced tendency for creep and/or stress relaxation, i.e. for semi-crystalline materials. If semi-crystalline materials are tested, pins are more appropriate than balls.

1.4 The ball impression method is useful for assessing the principal ESC behaviour of the material/chemical combination under consideration. It is less influenced by the near-surface orientation state of the specimens than the pin impression method and the methods in the other parts of this International Standard, where the chemical attacks only the original surface of the material. This, depending on the manner of specimen preparation, may show a considerable degree of orientation.

1.5 The pin impression method is useful for testing specimens of small thickness and finished parts.

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 178, *Plastics — Determination of flexural properties*

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*

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 527-1, *Plastics — Determination of tensile properties — Part 1: General principles*

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

ISO 2557-1, *Plastics — Amorphous thermoplastics — Preparation of test specimens with a specified maximum reversion — Part 1: Bars*

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

ISO 3167, *Plastics — Multipurpose test specimens*

ISO 3290, *Rolling bearings — Balls — Dimensions and tolerances*

ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

3 Terms and definitions

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

3.1
oversize
d_d
difference between the diameter of an impressed ball or pin (d_b) and the diameter of the drilled and reamed hole (d_h) in the test specimen:

$$d_d = d_b - d_h \quad (1)$$

3.2
deformation step
determination made at a defined oversize

3.3
deformation step zero
determination made using test specimens that are drilled and reamed only, i.e. without impressing a ball or pin

3.4
deformation series
number of successive deformation steps beginning with deformation step zero

NOTE Normally, a deformation series consists of seven deformation steps of increasing severity.

3.5
failure limit
oversize in a deformation series that produces failure, as specified in terms of the following failure criteria:

a) for type A test specimens (test specimens taken from products), as visible cracks, observable by means of a lens of magnification ×5;

b) for type B test specimens (moulded or machined test specimens), by the following criteria (see 9.2 and Figure 4):

1) a 5 % reduction in the maximum tensile force measured at deformation step zero (criterion B1 in Figure 1),

2) a 5 % reduction in the maximum flexural force measured at deformation step zero (criterion B2 in Figure 1),

3) a 20 % reduction in the tensile elongation at rupture measured at deformation step zero (criterion B3 in Figure 1).

NOTE 1 If there is no rupture immediately after application of the maximum tensile force, the tensile elongation at 50 % of the preceding maximum tensile force (see Figure 1) may be measured. Failure is then defined by a 20 % reduction in the value at deformation step zero (criterion B4).

NOTE 2 It is sufficient to measure the elongation at break between the grips.

NOTE 3 If the value of the tensile stress is required, refer the force to the smallest cross-sectional area of the specimen at the location of the hole. Calculate the tensile stress in accordance with Equation (2):

$$\sigma = \frac{F}{h \cdot (w - d_\mathrm{h})} \tag{2}$$

where

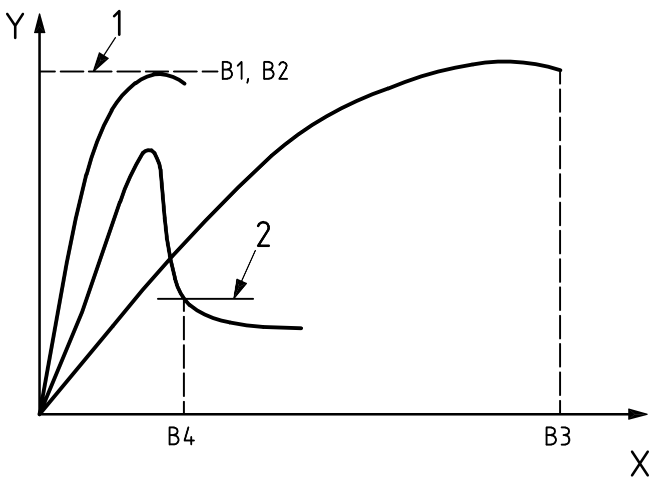
σ is the tensile stress, in MPa or N·mm^{-2};

F is the tensile force, in N;

h is the thickness of the specimen, in mm;

d_h is the diameter of the hole, after reaming, in mm;

w is the width of the specimen, in mm.



Key

X elongation
Y stress
1 maximum
2 0,5 × preceding max. tensile force
B1 5 % reduction in the maximum tensile force
B2 5 % reduction in the maximum flexural force
B3 20 % reduction in the tensile elongation at rupture
B4 tensile elongation at 50 % of the preceding maximum tensile force

Figure 1 — Failure criteria for type B test specimens

3.6
relative stress-cracking factor
ratio of the failure limit in the test environment to that in a reference environment, for example air, measured at the same test temperature after the same test time

4 Principle

A constant strain, produced by impressed balls or pins in a test specimen in a test environment, often generates micro-cracks that may, in time, develop into visible cracks. To shorten the time for the test, failure may be accelerated by subsequent mechanical testing. If products cannot be assessed by mechanical tests, visual examination for cracks around the balls or pins may be undertaken.

A hole of specified diameter is drilled in a test specimen, an oversize ball or pin is inserted into the hole and the specimen is brought into contact with a chemical medium. This procedure is repeated using balls or pins of progressively greater diameter. After a specified time, the effect of the interaction is determined by visual examination (type A test specimens) or by the determination of the tensile or flexural properties (type B test specimens). A parallel series of tests may be performed in which the test specimens are exposed to air, and the comparative behaviour determined.

NOTE Pins are suitable for a single series of test specimens or articles of thickness greater than 1 mm. The deformation of the test specimen is the same along the whole length of the hole. Balls are suitable for thicknesses greater than 2 mm. The preferred thickness is 4 mm.

5 Apparatus

5.1 Drilling machine, operating at a suitable frequency of rotation, for example at 1 000 min^{-1}.

5.2 Drills, of diameter (2,8 ± 0,1) mm.

5.3 Reamer, suitable for finishing a hole of diameter (3,00 ± 0,05) mm.

NOTE A 3H7 reamer (3,004 mm to 3,008 mm) is suitable.

5.4 Plug gauges, or other suitable devices, for measuring the diameters of the reamed holes to within 0,005 mm.

5.5 Micrometer, for determining the diameters of the pins with an accuracy of 0,001 mm.

5.6 Polished steel balls or **pins**, having tolerances of ± 0,001 mm on diameters up to 4 mm and ± 0,01 mm on diameters greater than 4 mm.

NOTE If steel is attacked in the test environment, other suitable hard materials, for example glass, may be used for the balls or pins.

The use of the ranges of diameters given in Table 1 is recommended.

5.6.1 Balls, conforming to ISO 3290 grade G20 for diameters up to 4 mm and grade G200 for diameters greater than 4 mm.

5.6.2 Pins, free of roughness or sharp edges, having a parallel-sided part 10 mm to 50 mm long and a taper (1:5) at one end to reduce the entry diameter to 2,5 mm (see Figure 2). The surface roughness of the pins shall be equal, preferably with $Ra < 0,02$ µm (see ISO 4287).

NOTE A longer parallel-sided part of the pin will allow several test specimens to be tested with the same pin.

5.7 Jig, for drilling and reaming the holes (a typical fixture is shown in Figure 3).

5.8 Apparatus for pressing the balls or pins into the hole.

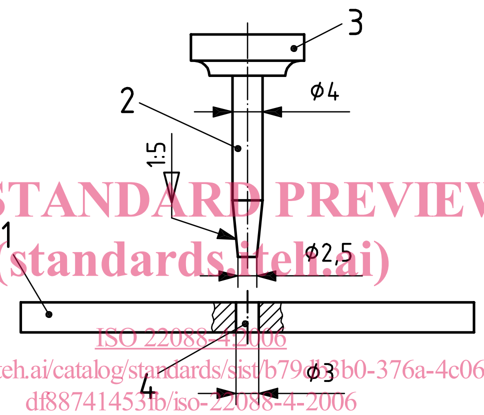
The spindle of the drilling machine or the tensile-testing machine itself may be used.

Table 1 — Recommended ranges of diameter for balls and pins

Dimensions in millimetres

Diameter	Increment
2,98 to 3,20	0,01
3,20 to 3,50	0,05
3,50 to 4,00	0,10
4,0 to 6,0	0,50

Dimensions in millimetres

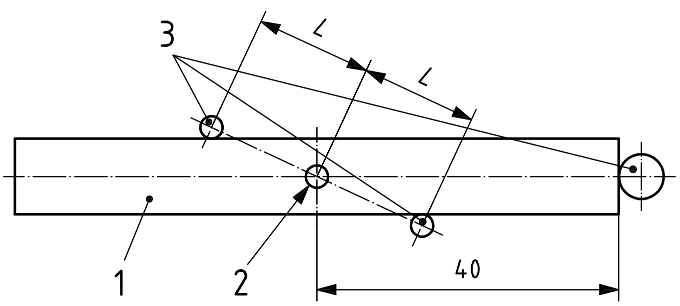


Key

1 test specimen
2 pin
3 presser foot of test machine
4 drill hole

Figure 2 — Example of pin construction and insertion of the pin

Dimensions in millimetres



Key

1 test specimen
2 hole
3 holding pins

Figure 3 — Typical fixture for drilling holes in test specimens

