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ISO 6603-2

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Plastics — Determination of puncture impact behaviour of rigid plastics —

Part 2: Instrumented impact testing

Plastiques — Détermination du comportement des plastiques rigides perforés sous l'effet d'un choc —

Partie 2: Essais de choc instrumentés

Reference number
ISO 6603-2:2000(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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 6603 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 6603-2 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

This second edition cancels and replaces the first edition (ISO 6603-2:1989), which has been technically revised.

ISO 6603 consists of the following parts, under the general title *Plastics — Determination of puncture impact behaviour of rigid plastics*:

— *Part 1: Non-instrumented impact testing*

— *Part 2: Instrumented impact testing*

Annexes A to E of this part of ISO 6603 are for information only.

Plastics — Determination of puncture impact behaviour of rigid plastics —

Part 2:
Instrumented impact testing

1 Scope

This part of ISO 6603 specifies a test method for the determination of puncture impact properties of rigid plastics, in the form of flat specimens, using instruments for measuring force and deflection. It is applicable if a force-deflection or force-time diagram, recorded at nominally constant striker velocity, is necessary for detailed characterization of the impact behaviour.

ISO 6603-1 can be used if it is sufficient to characterize the impact behaviour of plastics by a threshold value of impact-failure energy based on many test specimens.

It is not the purpose of this part of ISO 6603 to give an interpretation of the mechanism occurring on every particular point of the force-deflection diagram. These interpretations are a task for scientific research.

NOTE See also clause 1 of ISO 6603-1:2000.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 6603. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 6603 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 2602:1980, *Statistical interpretation of test results — Estimation of the mean — Confidence interval.*

ISO 6603-1:2000, *Plastics — Determination of puncture impact behaviour of rigid plastics — Part 1: Non-instrumented impact testing*.

3 Terms and definitions

For the purposes of this part of ISO 6603, the following terms and definitions apply.

3.1
impact velocity
v_0
velocity of the striker relative to the support at the moment of impact

NOTE Impact velocity is expressed in metres per second (m/s).

3.2
force
F
force exerted by the striker on the test specimen in the direction of impact

NOTE Force is expressed in newtons (N).

3.3
deflection
l
relative displacement between the striker and the specimen support, starting from the first contact between the striker and the test specimen

NOTE Deflection is expressed in millimetres (mm).

3.4
energy
E
energy expended in deforming and penetrating the test specimen up to a deflection l

NOTE 1 Energy is expressed in joules (J).

NOTE 2 Energy is measured as the integral of the force-deflection curve starting from the point of impact up to a deflection l.

3.5
maximum force
F_M
maximum force occurring during the test

See Figures 1 to 4.

NOTE Maximum force is expressed in newtons (N).

3.6
deflection at maximum force
l_M
deflection that occurs at maximum force F_M

See Figures 1 to 4.

NOTE Deflection at maximum force is expressed in millimetres (mm).

3.7
energy to maximum force
E_M
energy expended up to the deflection l_M at maximum force

See Figures 1 to 4.

NOTE Energy to maximum force is expressed in joules (J).

3.8
puncture deflection
l_P
deflection at which the force has dropped to half the maximum force F_M

See Figures 1 to 4 and note to 3.9.

NOTE Puncture deflection is expressed in millimetres (mm).

3.9
puncture energy
E_P
energy expended up to the puncture deflection l_P

See Figures 1 to 4 and note 2.

NOTE 1 Puncture energy is expressed in joules (J).

NOTE 2 When testing tough materials, a transducer mounted at some distance from the impacting tip may record frictional force acting between the cylindrical part of the striker and the punctured material. The corresponding frictional energy shall not be included in the puncture energy, which, therefore, is restricted to that deflection, at which the force drops to half the maximum force F_M.

3.10
impact failure
mechanical behaviour of the material under test which may be either one of the following types (see note):

a) **YD** **y**ielding (zero slope at maximum force) followed by **d**eep drawing

b) **YS** **y**ielding (zero slope at maximum force) followed by (at least partially) **s**table cracking

c) **YU** **y**ielding (zero slope at maximum force) followed by **u**nstable cracking

d) **NY** **n**o **y**ielding

See Figures 1 to 4.

NOTE Comparison of Figures 2 and 3 shows puncture deflection l_P and puncture energy E_P are identical for the failure types YS and YU. As shown in Figure 4, identical values at maximum and at puncture are found for the deflection as well as the energy in the case of failure type YU. For complex behaviour see annex A.

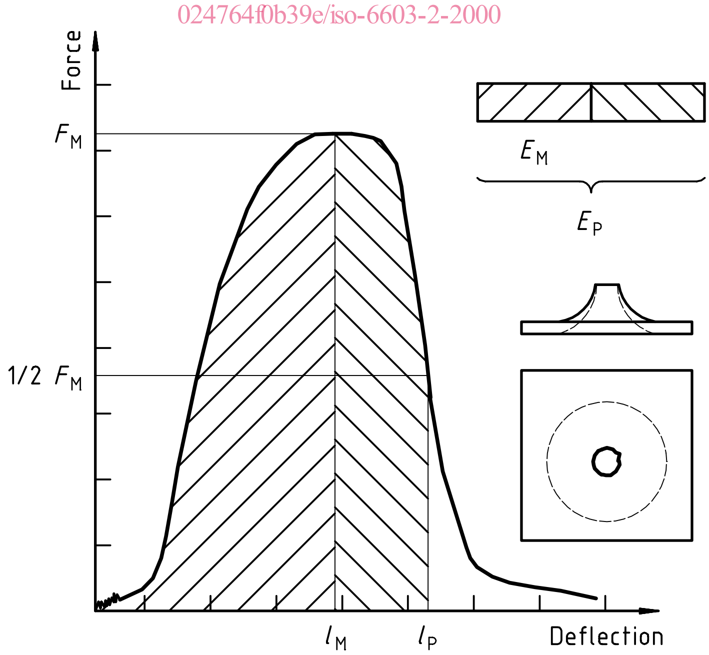


Figure 1 — Example of force-deflection diagram for failure by yielding (zero slope at maximum force) followed by deep drawing, and typical appearance of specimens after testing (with lubrication)

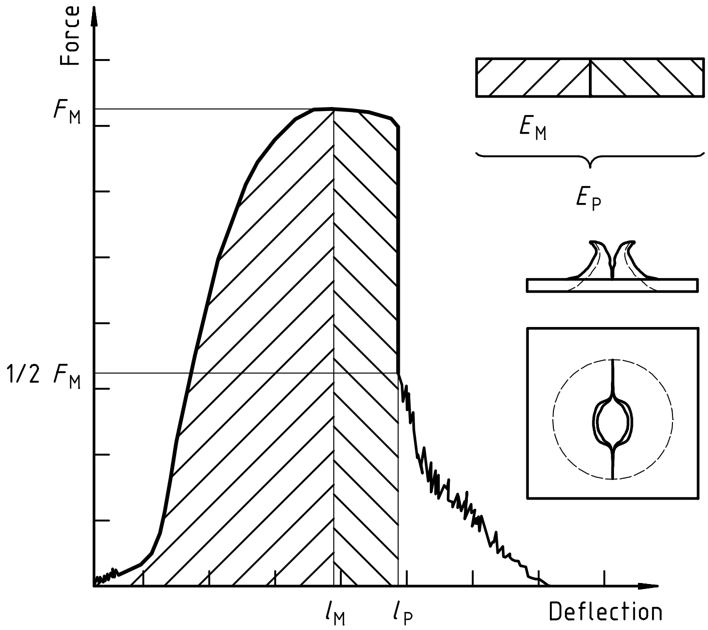
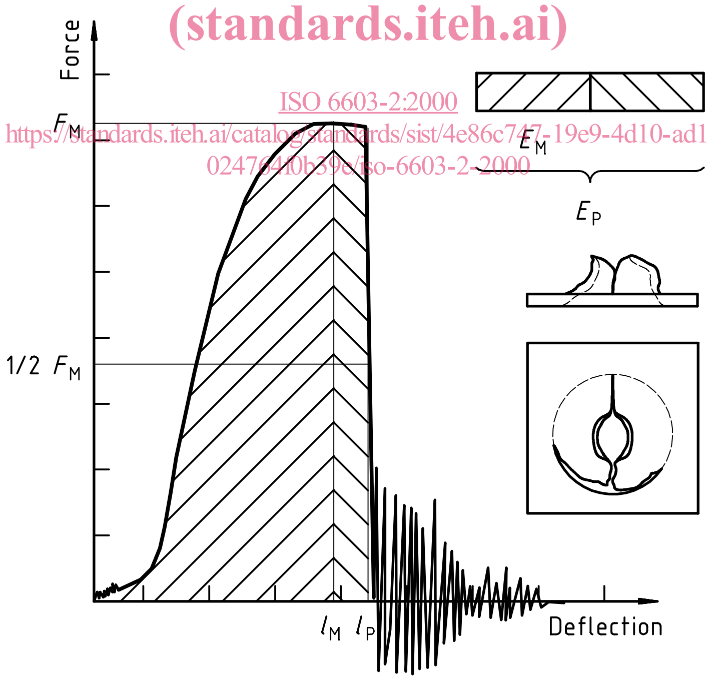


Figure 2 — Example of force-deflection diagram for failure by yielding (zero slope at maximum force) followed by stable crack growth, and typical appearance of specimens after testing (with lubrication)



NOTE Natural vibration of the force detector can be seen after unstable cracking (striker and load cell).

Figure 3 — Example of force-deflection diagram for failure by yielding (zero slope at maximum force) followed by unstable crack growth, and typical appearance of specimens after testing (with lubrication)

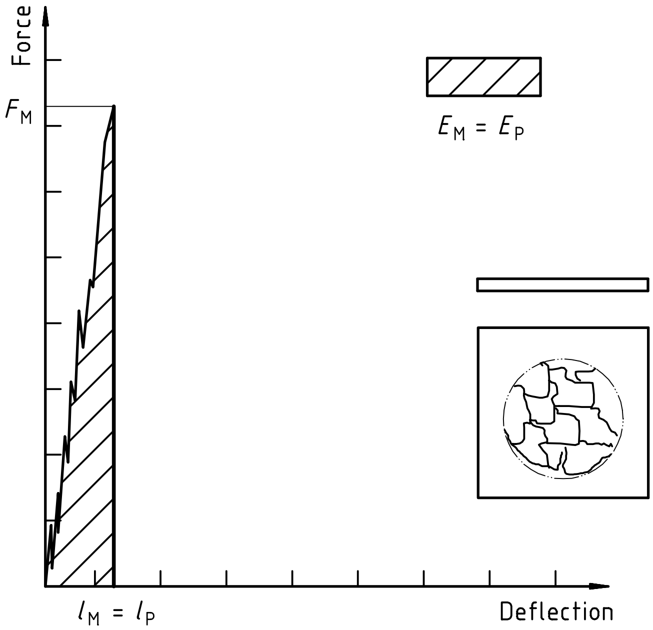


Figure 4 — Example of force-deflection diagram for failure without yielding followed by unstable crack growth, and typical appearance of specimens after testing (with lubrication)

4 Principle

The test specimen is punctured at its centre using a lubricated striker, perpendicularly to the test-specimen surface and at a nominally uniform velocity. The resulting force-deflection or force-time diagram is recorded electronically. The test specimen may be clamped in position during the test.

The force-deflection diagram obtained in these tests records the impact behaviour of the specimen from which several features of the behaviour of the material may be inferred.

5 Apparatus

5.1 Testing device, consisting of the following essential components:

— energy carrier, which may be inertial-mass type or hydraulic type (see 5.1.1);

— striker, which shall be lubricated;

— specimen support with a recommended clamping device.

The test device shall permit the test specimen to be punctured at its centre, perpendicular to its surface at a nominally constant velocity. The force exerted on the test specimen in the direction of impact and the deflection from the centre of the test specimen in the direction of impact shall be derivable or measurable (see Figure 5).

5.1.1 Energy carrier, with a preferred impact velocity v_0 of (4,4 ± 0,2) m/s (see 3.1 and note to 3.1). To avoid results, which cannot be compared due to the viscoelastic behaviour of the material under impact, the decrease of velocity during the test shall not be greater than 20 %.

NOTE For brittle materials, an impact velocity of 1 m/s may be found to be more appropriate because it reduces the level of vibration and noise and improves the quality of the force-deflection diagram (see annex A).

5.1.1.1 Hydraulic type, consisting of a high-speed testing machine with suitable attachments.

Any deviation of the velocity of the striker relative to the support during impact shall be controlled, for example by recording deflection-time curves and checking the slope.

5.1.1.2 Inertial-mass type, which may be accelerated gravitationally, spring- or pneumatically-assisted. Suitable devices are falling-dart machines.

In the case of a gravitationally accelerated mass and neglecting frictional losses; the impact velocity v_0 corresponds to a drop height H_0 of the energy carrier of (1,0 ± 0,1) m.

For all inertial-mass-type energy carriers the impact velocity shall be measured by velocity-measuring sensors placed close to the point of impact. The maximum decrease of velocity during test results in the minimum mass, m_C, of the carrier according to equations (1) and (2) (see note).

$$m_C \geqslant 6\, E^*/v_0^2 \tag{1}$$

$$m_C \geqslant 0{,}31\, E^* \quad \text{for } v_0 = 4{,}4 \text{ m/s} \tag{2}$$

where

m_C is the mass of the energy carrier, expressed in kilograms;

E^* is the highest puncture energy to be measured, expressed in joules (see 3.9);

v_0 is the impact velocity (4,4 m/s, see 3.1).

NOTE In many cases, a weighted energy carrier with a total mass m_C of 20 kg has been found to be sufficient for the larger striker and of 5 kg for the smaller striker (see 5.1.2).

5.1.2 Striker, preferably having a polished hemispherical striking surface of diameter (20,0 ± 0,2) mm. Alternatively, a (10 ± 0,1) mm diameter striking surface may be used.

NOTE 1 The size and dimensions of the striker and condition of the surface will affect the impact results.

The striker shall be made of any material with sufficient resistance to wear and of sufficiently high strength to prevent plastic deformation. In practice, hardened steel or materials with lower density (i.e. titanium) have been found acceptable.

The hemispherical surface of the striker shall be lubricated to reduce any friction between the striker and the test specimen (see note 2 and annex B).

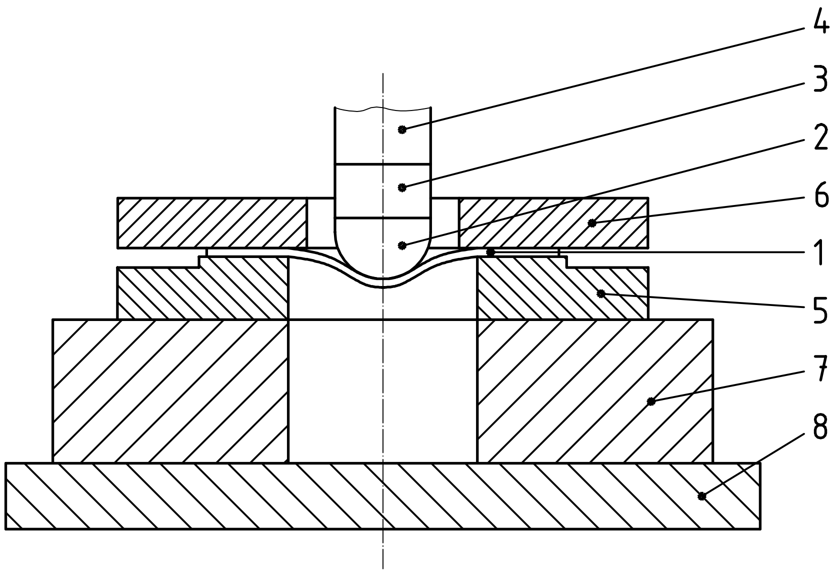
NOTE 2 Test results obtained with a lubricated or dry striker are likely to be different. Below ambient temperatures, condensation can act as a lubricant.

The load cell shall be located within one striker diameter from the tip of the striker, i.e. mounted as closely as possible to the tip to minimize all extraneous forces and sufficiently near to fulfil the frequency-response requirement (see 5.2). An example is shown in Figure 5.

5.1.3 Support ring (see Figures 5 and 6)**,** placed on a rigid base and designed such that air can not be trapped under the test specimen, thus avoiding a possible spring effect. Below the support ring, there shall be sufficient space for the striker to travel after total penetration of the test specimen. The recommended inside diameter of the support ring is (40 ± 2) mm, or alternatively (100 ± 5) mm, with a minimum height of 12 mm.

5.1.4 Base for test device, firmly mounted to a rigid structure so that the mass of the base (see Figure 5) is of sufficient stiffness to minimize deflection of the specimen support.

When calculating the deflection from the kinetics of the accelerated mass, a minimum mass ratio m_B/m_C of 10 between base (m_B) and energy carrier (m_C) shall be used. This prevents the base from being accelerated by more than 1 % of the impact speed up to the end of the test. For directly measured deflections, this minimum ratio is a recommendation only. For the principles of this specification see annex B of ISO 179-2:1997 [5].



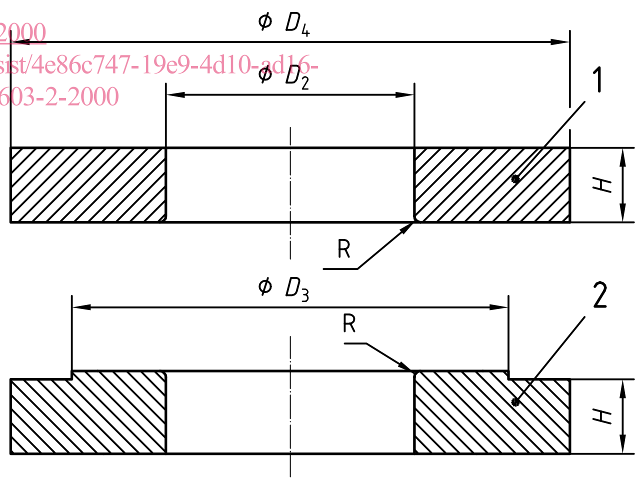
Key

1 Test specimen
2 Hemispherical striker tip
3 Load cell (preferred position)
4 Shaft
5 Test specimen support
6 Clamping ring (optional)
7 Base
8 Acoustical isolation (optional)

Figure 5 — Example of test device

Dimensions in millimetres

Specimen type	Side of square or diameter of disc	
	60	140
D_2	40 ± 2	100 ± 5
D_3	60	140
D_4	⩾ 90	⩾ 200
H	12	12
R	1	1



Key

1 Clamping ring (optional)
2 Test specimen support

Figure 6 — Clamping device (schematic)

5.1.5 Clamping device (optional), consisting of two parts, a supporting ring and a clamping ring (see Figure 6), for annular test specimens. The recommended inside diameter of the clamping device is (40 ± 2) mm, alternatively (100 ± 5) mm. The clamp may work by shape or by application of force to the specimen. A clamping force of 3 kN is recommended for the latter (see note).

NOTE Pneumatically and screw-operated clamps have been successfully employed. The results obtained for clamped and unclamped specimens are likely different (see annex C).