INTERNATIONAL STANDARD

ISO 8256

Second edition
2004-07-01

Plastics — Determination of tensile-impact strength

Plastiques — Détermination de la résistance au choc-traction

Reference number
ISO 8256:2004(E)

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

© ISO 2004

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

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

Published in Switzerland

Copyright International Organization for Standardization
Reproduced by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Contents

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 8256 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

This second edition cancels and replaces the first edition (ISO 8256:1990), which has been technically revised.

Plastics — Determination of tensile-impact strength

1 Scope

1.1 This International Standard specifies two methods (method A and method B) for the determination of the tensile-impact strength of plastics under defined conditions. The tests can be described as tensile tests at relatively high strain rates. These methods can be used for rigid materials (as defined in ISO 472), but are especially useful for materials too flexible or too thin to be tested with impact tests conforming to ISO 179 or ISO 180.

1.2 These methods are used for investigating the behaviour of specified specimens under specified impact velocities, and for estimating the brittleness or the toughness of specimens within the limitations inherent in the test conditions.

1.3 These methods are applicable both to specimens prepared from moulding materials and to specimens taken from finished or semi-finished products (for example mouldings, laminates, or extruded or cast sheets).

1.4 Results obtained by testing moulded specimens of different dimensions may not necessarily be the same. Equally, specimens cut from moulded products may not give the same results as specimens of the same dimensions moulded directly from the material. Test results obtained from specimens prepared from moulding compounds cannot be applied directly to mouldings of any given shape, because values may depend on the design of the moulding and the moulding conditions. Results obtained by method A and method B may or may not be comparable.

1.5 These methods are not suitable for use as a source of data for design calculations on components. Information on the typical behaviour of a material can be obtained, however, by testing different types of test specimen prepared under different conditions, and by testing at different temperatures. The two different methods are suitable for production control as well as for quality control.

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 179-1, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

ISO 179-2, *Plastics — Determination of Charpy impact properties — Part 2: Instrumented impact test*

ISO 180, *Plastics — Determination of Izod impact strength*

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 294-2, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 2: Small tensile bars*

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

ISO 295, *Plastics — Compression moulding of test specimens of thermosetting materials*

ISO 472, *Plastics — Vocabulary*

ISO 1268 (all parts), *Fibre-reinforced plastics — Methods of producing test plates*

ISO 2602, *Statistical interpretation of tests results — Estimation of the mean — Confidence interval*

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

ISO 3167, *Plastics — Multipurpose test specimens*

ISO 10350-1, *Plastics — Acquisition and presentation of comparable single-point data — Part 1: Moulding materials*

ISO 11403-3, *Plastics — Acquisiton and presentation of comparable multipoint data — Part 3: Environmental influences on properties*

ISO 13802, *Plastics — Verification of pendulum impact-testing machines — Charpy, Izod and tensile impact-testing*

3 Terms and definitions

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

3.1
tensile-impact strength of unnotched specimens

a_{tU}

energy absorbed in breaking an unnotched specimen under specified conditions, referred to the original cross-sectional area of the specimen

NOTE It is expressed in kilojoules per square metre (kJ/m^2).

3.2
tensile-impact strength of notched specimens

a_{tN}

energy absorbed in breaking a notched specimen under specified conditions, referred to the original cross-sectional area of the specimen at the notch

NOTE It is expressed in kilojoules per square metre (kJ/m^2).

4 Principle

A specimen is broken by a single impact at the bottom of the swing of the pendulum of a tensile-impact machine. The specimen is horizontal at the moment of rupture. One end of the specimen, at impact, is held either by the frame or the pendulum and the other end by the crosshead. The two methods described are based on two different ways of positioning the specimen held by the crosshead: the specimen may be either mounted stationary on the support frame (method A) or carried downward together with the pendulum (method B).

The energy to fracture is determined by the kinetic energy extracted from the pendulum in the process of breaking the specimen. Corrections are made for the energy to toss (method A) or bounce (method B) the crosshead.

5 Apparatus

5.1 Test machine

The principles, characteristics and verification of suitable test machines are detailed in ISO 13802.

5.2 Pendulum and striker

5.2.1 The pendulum shall be constructed of a single- or multiple-membered arm holding the head, in which the greatest mass is concentrated. A rigid pendulum is essential to maintain the proper clearances and geometric relationships between related parts and to minimize energy losses, which are always included in the measured impact-energy value.

5.2.2 The strikers for method A and method B are described in detail in ISO 13802.

5.3 Crosshead

5.3.1 As pointed out in ISO 13802, in order to reduce bouncing due to the impact of the metal striker on the metal crosshead, the material used for the crosshead shall be one which gives an essentially inelastic impact (e.g. aluminium). The mass of the crosshead, both for method A and for method B, shall be selected from the values given in Table 1.

5.3.2 A jig or other device shall be used to assist in clamping the crosshead in the specified position, at right angles to the longitudinal axis of the specimen.

Table 1 — Crosshead masses

Potential energy J	**Crosshead mass** g	
	Method A	**Method B**
2,0	15 ± 1 or 30 ± 1	15 ± 1
4,0	15 ± 1 or 30 ± 1	15 ± 1
7,5	30 ± 1 or 60 ± 1	30 ± 1
15,0	30 ± 1 or 60 ± 1	120 ± 1
25,0	60 ± 1 or 120 ± 1	120 ± 1
50,0	60 ± 1 or 120 ± 1	120 ± 1

NOTE For method A, use the lighter crosshead whenever possible.

5.4 Clamping devices/jaws

Clamps and jaws for tensile-impact testing are described in ISO 13802.

5.5 Micrometers and gauges

Micrometers and gauges suitable for measuring the dimensions of test specimens to an accuracy of 0,01 mm are required. In measuring the thickness of the specimen, the measuring face shall apply a load of 0,01 MPa to 0,05 MPa. For notched specimens, see the requirements of 7.4.

6 Test specimens

6.1 Shape and dimensions

Five types of test specimen, as specified in Table 2 and shown in Figure 1, may be used. In general, all types can be used with either of the two methods.

Method A: To be in agreement with ISO 10350-1 and ISO 11403-3, the preferred specimen types are type 1 (which can be taken from the multipurpose test specimen specified in ISO 3167 or moulded directly in accordance with ISO 294-1) and type 4 (which can be moulded directly in accordance with ISO 294-2 or machined from plates moulded in accordance with ISO 294-3).

Method B: The preferred specimen types are type 2 and type 4.

The test result depends on the type of specimen used and its preparation and thickness. For reproducible results, or in cases of dispute, the type of test specimen and its preparation and thickness shall be agreed upon.

Specimens are tested at their original thickness up to and including 4 mm. The preferred specimen thickness is 4 mm ± 0,2 mm for type 1 specimens and 3 mm ± 0,2 mm for type 4 specimens. Within the gauge area, the thickness shall be maintained to within a tolerance of ± 5 %. Above 4 mm, the test methods described in this International Standard are inapplicable, and ISO 179 or ISO 180 have to be used to determine the impact properties of specimens.

Table 2 — Specimen types and dimensions

Dimensions in millimetres

Specimen type	**Length** l	**Width** b	**Preferred value of dimension** x	**Preferred value of dimension** l_0	**Free length between grips** l_e	**Radius of curvature** r
1	80 ± 2	10 ± 0,2	6 ± 0,2	—	30 ± 2	—
2	60 ± 2	10 ± 0,2	3 ± 0,2	10 ± 0,2	25 ± 2	10 ± 1
3	80 ± 2	15 ± 0,2	10 ± 0,2	10 ± 0,2	30 ± 2	20 ± 1
4	60 ± 2	10 ± 0,2	3 ± 0,2	—	25 ± 2	15 ± 1
5[a]	80 ± 2	15 ± 0,2	5 ± 0,2	10 ± 0,2	50 ± 2	20 ± 1

[a] For type 5: b' = 23 mm ± 2 mm, r' = 4 mm ± 0,5 mm, l' = 11 mm ± 1 mm.

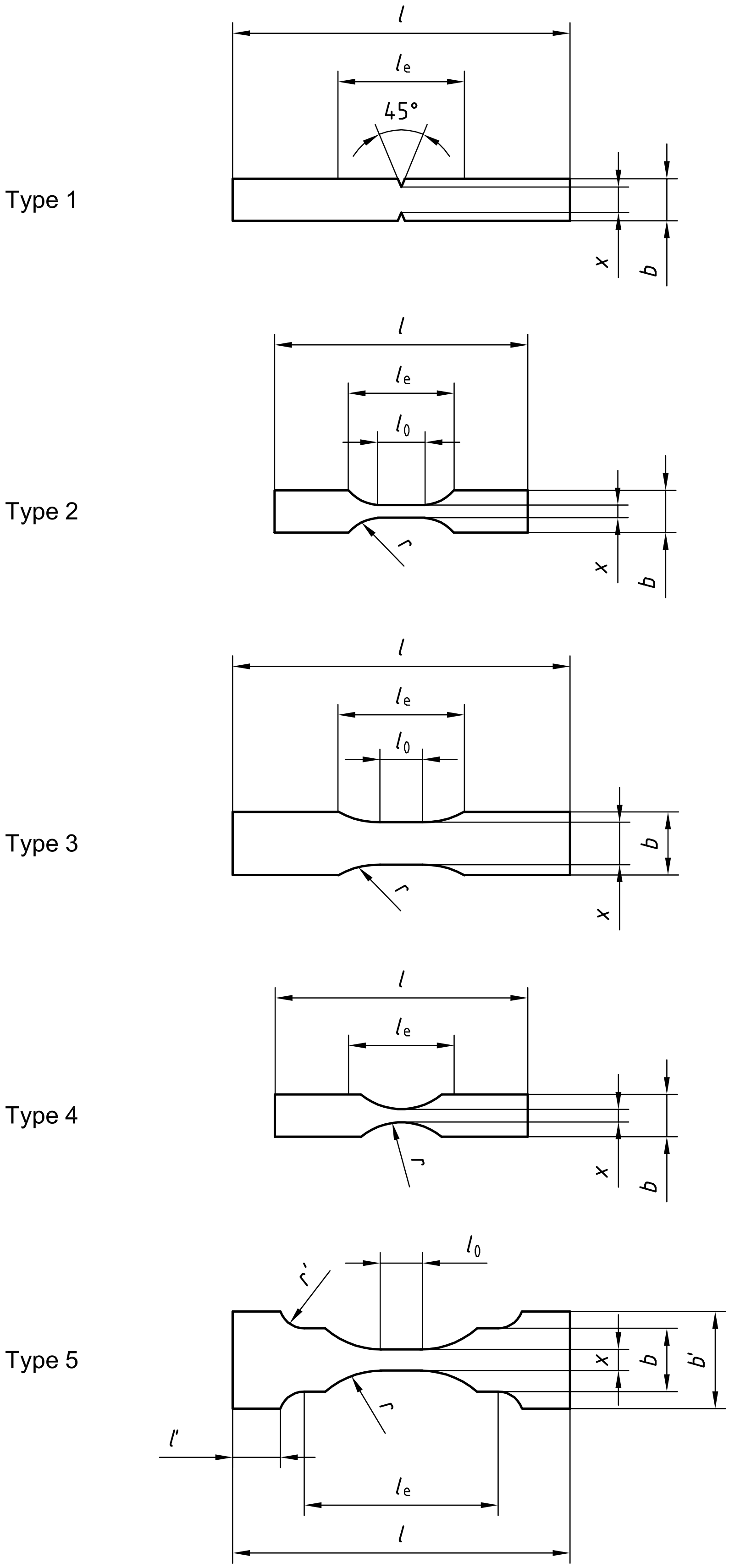


Figure 1 — Types of test specimen

6.2 Preparation

6.2.1 Moulding and extrusion compounds

Specimens shall be prepared in accordance with the relevant material specification. When none exists, or when otherwise specified, specimens shall be directly extruded (in accordance with the standard appropriate to the material), or compression or injection moulded from the material in accordance with ISO 293, ISO 294-1, ISO 294-2 or ISO 295, or machined in accordance with ISO 2818 from sheets or plates compression or injection moulded from the compound. Type 1 specimens can be prepared from the type A multi-purpose test specimen described in ISO 3167.

6.2.2 Sheets

Specimens shall be machined from sheets in accordance with ISO 2818.

6.2.3 Fibre-reinforced resins

A panel shall be prepared from the compound in accordance with the relevant part of ISO 1268, and specimens shall be machined in accordance with ISO 2818.

6.3 Notching of specimens

6.3.1 Notches (for type 1 specimens) shall be machined in accordance with ISO 2818 on unnotched specimens prepared in accordance with 6.2.

6.3.2 The radius of the notch base shall be 1,0 mm ± 0,05 mm and its angle 45° ± 1° (see Figure 1). The profile of the cutting tooth shall be such as to produce in the specimen, at right angles to its principal axis, two notches of the contour and depth shown in Figure 1. The two lines drawn perpendicular to the length direction of the specimen through the apex of each notch shall be within 0,2 mm of each other. Particular attention shall be given to the accuracy of the dimension x (see Table 2). Close tolerances have to be imposed on the contour and the radius of the notch for most materials because these factors largely determine the degree of stress concentration at the base of the notch during the test. The maintenance of a sharp, clean-edged cutting tool is particularly important since minor defects at the base of the notch can cause large deviations in the test results. The profile of the notch being produced by a particular cutting tool shall be checked at regular intervals.

6.3.3 Specimens with moulded-in notches may be used if specified for the material being tested. Specimens with moulded-in notches generally do not give the same results as specimens with machined notches, and allowance should be made for this difference in interpreting the results. Specimens with machined notches are generally preferred because skin effects and/or localized anisotropy are minimized. The profile of the notch being produced shall be checked at regular intervals.

6.3.4 For specimens prepared by cutting them out with a puncher, the notch shall not be punched out but shall be machined in a second step.

6.4 Number of test specimens

Unless otherwise specified in the standard for the material being tested, a set consisting of ten specimens shall be tested. When the coefficient of variation (see ISO 2602) has a value of less than 5 %, a minimum number of five test specimens is sufficient.

6.5 Anisotropy

The impact properties of certain types of sheet material may differ depending on the direction of measurement in the plane of the sheet. In such cases, it is customary to prepare two groups of test specimens with their major axes respectively parallel and perpendicular to the direction of some feature of the sheet which is either visible or can be inferred from knowledge of the method of manufacture of the sheet.

6.6 Conditioning

Unless otherwise specified in the standard for the material being tested, the specimens shall be conditioned in accordance with ISO 291, unless other conditions are agreed upon by the interested parties. In the case of notched specimens, the conditioning time starts after notching.

7 Procedure

7.1 Conduct the test in the same atmosphere as that used for conditioning, unless other conditions are agreed upon by the interested parties (e.g. for testing at high or low temperature).

7.2 Check that the impact machine is able to perform the test with the specified velocity of impact and that the energy absorbed is in the correct range, i.e. between 20 % and 80 % of the energy available at impact. If more than one of the pendulums conform to these requirements, the pendulum having the highest energy shall be used.

7.3 Determine the frictional losses in accordance with ISO 13802.

7.4 Measure the thickness h and the width x of the central, parallel-sided section of the test specimen to the nearest 0,02 mm. In the case of notched specimens, carefully measure the dimension x using a micrometer fitted with an anvil of width 2 mm to 3 mm and of suitable profile to fit the shape of the notch.

In the case of injection-moulded specimens, it is not necessary to measure the dimensions of each specimen. It is sufficient to measure one specimen from a set to make sure that the dimensions correspond to those requested. With multiple-cavity moulds, ensure that the dimensions of the specimens are the same for each cavity.

7.5 Lift the pendulum to the prescribed height and arrest it. Insert the specimen in the holder and tighten firmly: for method A, place one end of the specimen inside the vice jaw of the frame and the other inside the crosshead clamp; for method B, place one end of the specimen inside the secured specimen clamp and the other inside the unsecured crosshead/specimen clamp (see ISO 13802 for details).

7.6 Release the pendulum. Record the impact energy E_S absorbed by the specimen and apply corrections for frictional losses if necessary in accordance with ISO 13802.

7.7 If the resulting corrected tensile-impact energy is below 20 % of the capacity of the 2,0 J pendulum, the data should be considered suspect.

In cases where the specimen is weak, rigid multi-layered specimens may be used. Use of such specimens shall be by agreement between the interested parties and shall be clearly documented in the test report.

7.8 If various materials are to be compared, pendulums with the same velocity at impact shall be used for each. In cases of dispute, it is recommended that test results be compared only with results obtained with pendulums of identical nominal energy and specimens of the same geometry.

7.9 Immediately after the test has been completed, a check shall be made to ensure that the specimen was firmly clamped or whether it had slipped in one of the two grips, and that the failure occurred in the narrow, parallel-sided part of the specimen. If any of the specimens tested do not meet these requirements, the results for these specimens shall be discarded and additional specimens tested.

8 Determination of energy corrections

8.1 Method A — Correction E_q due to the plastic deformation and the kinetic energy of the crosshead

The correction E_q is determined from the following equation (see Annex A for details):

$$E_q = \frac{E_{max} \times \mu \times (3 + \mu)}{2 \times (1 + \mu)} \approx \frac{3}{2} \times E_{max} \times \mu \qquad (1)$$

where

E_q is the energy correction, in joules, due to the plastic deformation and the kinetic energy of the crosshead;

E_{max} is the maximum impact energy, in joules, of the pendulum;

μ is the mass of the crosshead divided by the reduced mass of the pendulum (i.e. m_{cr}/m_p).

The reduced mass of the pendulum m_p is given by the equation:

$$m_p = \frac{E_{max}}{g \times L_p \times (1 - \cos\alpha)} \qquad (2)$$

where

g is the acceleration, in m·s^{-2}, due to gravity;

L_p is the pendulum length, in metres, determined as indicated in ISO 13802;

α is the angle between the positions of the pendulum at its maximum and minimum height.

8.2 Method B — Crosshead-bounce energy E_b

The crosshead-bounce energy E_b is determined for each specimen and pendulum from the crosshead-bounce energy curve. This curve is determined only once for each crosshead and pendulum combination (see Annex B).

9 Calculation and expression of results

9.1 Calculation of corrected tensile-impact energy

9.1.1 General

In order to calculate the tensile-impact strength of the specimens, the consumed energy E_s must first be corrected for the toss energy E_q in method A and for the crosshead-bounce energy E_b in method B.

9.1.2 Energy correction for method A

The corrected tensile-impact energy E_c, in joules, is calculated using the equation:

$$E_c = E_s - E_q \qquad (3)$$

where

E_s is the impact energy, in joules, absorbed during the impact, as measured by the instrument (see 7.6);

E_q is the toss energy, in joules, due to the plastic deformation and the kinetic energy of the crosshead, calculated as specified in 8.1.

9.1.3 Energy correction for method B

The corrected tensile-impact energy E_c, in joules, is calculated using the equation:

$$E_c = E_s + E_b \tag{4}$$

where

E_s is the impact energy, in joules, measured by the instrument (see 7.6).

E_b is the crosshead-bounce energy, in joules, of the crosshead, as determined from the measured value of E_s and the graph prepared for the particular impact tester used, as specified in 8.2 and Annex B.

9.2 Calculation of tensile-impact strength

The tensile-impact strength a_{tU} or the tensile-impact strength (notched) a_{tN}, expressed in kilojoules per square metre, is calculated using the following equation:

$$a_{tU} \quad (a_{tN}) = \frac{E_c}{x \times h} \times 10^3 \tag{5}$$

where

E_c is the corrected impact energy, in joules, calculated in accordance with 9.1;

x is the width, in millimetres, of the narrow, parallel-sided section of the specimen (for specimen types 2, 3, 4 and 5 in Figure 1) or the distance between the notches (for specimen type 1 in Figure 1);

h is the thickness, in millimetres, of the narrow, parallel-sided section of the specimen [or, for multilayer specimens (see 7.7), the total thickness].

9.3 Statistical parameters

If required, calculate the arithmetic mean of test results, the standard deviation of the mean and the coefficient of variation using the procedure given in ISO 2602.

9.4 Number of significant figures

Report all calculated mean values to two significant figures.

10 Precision

The precision of this test method is not known because inter-laboratory data are not available. When inter-laboratory data are obtained, a precision statement will be added at the following revision.

11 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) the method (A or B) and specimen type (see Table 2) used:

Tensile impact test ISO 8256/1A
Type of specimen
Method

c) all information necessary for identification of the material tested, including type, source, manufacturer's code, grade and history, where these are known;

d) a description of the nature and form of the material, i.e., whether a product, semifinished product, sheet or specimen, including principal dimensions, shape, method of manufacture, etc., where these are known;

e) the thickness of moulded specimens or, for sheets, the thickness of the sheet and, if applicable, the directions of the major axes of the specimens in relation to some feature of the sheet;

f) the method of test specimen preparation;

g) the standard atmosphere used for conditioning and testing, plus any special conditioning treatment if required by the standard for the material or product;

h) the nominal pendulum energy;

i) the mass of the crosshead used;

j) the tensile-impact strength a_{tN} or a_{tU} of the material, expressed in kilojoules per square metre, reported as the arithmetic mean of the results on notched and/or unnotched test specimens, as applicable;

k) the individual test results, if required;

l) the standard deviation and the coefficient of variation of the results, if required;

m) the type of fracture exhibited by the test specimens;

n) the date of the test.

Annex A
(normative)

Determination of correction factor for method A

A.1 Energy terms used

In calculating the correction E_q, the following energy terms are used:

$$E_{\text{max}} = \frac{1}{2} \times m_p \times v_0^2 \qquad \text{(A.1)}$$

$$E_p = \frac{1}{2} \times m_p \times v_p^2 \qquad \text{(A.2)}$$

$$E_s = E_{\text{max}} - E_p \qquad \text{(A.3)}$$

$$E_{\text{cr,kin}} = \frac{1}{2} \times m_{\text{cr}} \times v_{\text{cr}}^2 \qquad \text{(A.4)}$$

As the elastic energy of the impact can be neglected (as required by 5.3.1, the impact is essentially inelastic), $v_{\text{cr}} = v_p$ and the kinetic energy of the crosshead is given by:

$$E_{\text{cr,kin}} = \frac{1}{2} \times m_{\text{cr}} \times v_p^2 \qquad \text{(A.5)}$$

where

E_{max} is the maximum impact energy, in joules, of the pendulum;

E_p is the residual energy, in joules, of the pendulum after the impact;

E_s is the measured energy, in joules, consumed during the impact;

$E_{\text{cr,kin}}$ is the kinetic energy, in joules, of the crosshead lost;

m_p is the reduced mass, in kilograms, of the pendulum (see 8.1);

v_0 is the velocity, in m·s^{-1}, of the pendulum immediately before impact;

v_p is the velocity, in m·s^{-1}, of the pendulum immediately after impact;

m_{cr} is the mass, in kilograms, of the crosshead;

v_{cr} is the velocity, in m·s^{-1}, of the crosshead immediately after impact.

In addition,

E_c is the energy, in joules, needed for deformation and fracture of the specimen (to be calculated);

$E_{\text{cr,pl}}$ is the energy, in joules, consumed by the plastic deformation of the crosshead.

A.2 Determination of $E_{\text{cr,kin}}$

The energy equation for the impact is:

$$E_{\text{s}} = E_{\text{c}} + E_{\text{cr,pl}} + E_{\text{cr,kin}} \tag{A.6}$$

Furthermore, from Equations (A.2) and (A.4), it follows that:

$$\frac{E_{\text{cr,kin}}}{E_{\text{p}}} = \mu \tag{A.7}$$

Combining this equation with Equation (A.3) gives:

$$E_{\text{cr,kin}} = \mu \times (E_{\text{max}} - E_{\text{s}}) \tag{A.8}$$

where

$$\mu = \frac{m_{\text{cr}}}{m_{\text{p}}} \tag{A.9}$$

A.3 Determination of $E_{\text{cr,pl}}$

To calculate the energy $E_{\text{cr,pl}}$ consumed by the plastic deformation of the crosshead, it is necessary to consider the momentum equation at impact without a specimen (i.e. $E_{\text{c}} = 0$).

This case is indicated by an asterisk (*).

The momentum equation (considering that the impact is essentially inelastic) can be written as follows:

$$m_{\text{p}} \times v_0 = (m_{\text{p}} + m_{\text{cr}}) \times v_{\text{p}}^{*} \tag{A.10}$$

Using Equation (A.9),

$$v_{\text{p}}^{*} = \frac{1}{1+\mu} \times v_0 \tag{A.11}$$

Considering Equation (A.3),

$$E_{\text{s}}^{*} = E_{\text{max}} - E_{\text{p}}^{*} \tag{A.12}$$

where

$$E_{\text{p}}^{*} = \frac{1}{2} \times m_{\text{p}} \times v_{\text{p}}^{*2} \tag{A.13}$$

and substituting Equations (A.1) and (A.13) in Equation (A.12) and using Equation (A.11), the consumed energy measured without a specimen is then given by:

$$E_{\text{s}}^{*} = E_{\text{max}} \times \frac{\mu \times (2+\mu)}{(1+\mu)^2} \tag{A.14}$$

With $E_c = 0$, Equation (A.6) becomes:

$$E_s^* = E_{cr,pl}^* + E_{cr,kin}^* \tag{A.15}$$

From Equations (A.5), (A.11) and (A.9), it follows that:

$$E_{cr,kin}^* = E_{max} \times \frac{\mu}{(1+\mu)^2} \tag{A.16}$$

Finally, from Equations (A.14), (A.15) and (A.16), the energy due to the plastic deformation of the crosshead, without any specimen, is given by:

$$E_{cr,pl}^* = E_{max} \times \frac{\mu}{(1+\mu)} \tag{A.17}$$

Since the crosshead is plastically deformed by the same amount with and without a specimen,

$$E_{cr,pl} = E_{cr,pl}^* \tag{A.18}$$

A.4 Energy correction

Considering Equation (A.6), the energy correction can be written as follows:

$$E_q = E_s - E_c = \mu \times \left[\frac{E_{max}}{(1+\mu)} + (E_{max} - E_s) \right] \tag{A.19}$$

This correction consists of a dominant constant part (representing the energy consumed by the plastic deformation of the crosshead $E_{cr,pl}$) and a smaller part ($E_{max} - E_s$) which decreases from μE_{max} to zero with increasing consumed energy (when $E_s \sim E_{max}$). In view of measurement uncertainties, it is sufficient to use a constant correction as an approximation; assuming that

$$E_s = \frac{E_{max}}{2} \tag{A.20}$$

gives the correction

$$E_q = E_s - E_c = \frac{E_{max} \times \mu \times (3+\mu)}{2 \times (1+\mu)} \tag{A.21}$$

The corrected value of the energy consumed by the impact with the specimen is therefore given by:

$$E_c = E_s - E_q = E_s - \frac{E_{max} \times \mu \times (3+\mu)}{2 \times (1+\mu)} \approx E_s - \frac{3}{2} \times \mu \times E_{max} \tag{A.22}$$

Annex B
(normative)

Determination of bounce-correction factor for method B

After impact and rebound of the crosshead, the specimen is pulled by two moving bodies, the pendulum with an energy of 0,5MV^2, and the crosshead with an energy of 0,5mv^2. When the specimen breaks, only that energy is recorded on the pendulum dial which is lost by the pendulum. Therefore, it is necessary to add the incremental energy contributed by the crosshead to determine the true energy used to break the specimen. The correction (i.e. the incremental energy contributed by the crosshead) can be calculated as follows:

By definition,

$$E = \frac{1}{2} \times M(V^2 - V_2^2) \qquad \text{(B.1)}$$

and

$$e = \frac{1}{2} \times m(v_1^2 - v_2^2) \qquad \text{(B.2)}$$

where

M is the mass, in kilograms, of the pendulum;

m is the mass, in kilograms, of the crosshead;

V is the maximum velocity, in metres per second, of the centre of impact of the crosshead;

V_2 is the velocity, in metres per second, of the centre of impact of the pendulum at the moment when the specimen breaks;

v_1 is the crosshead velocity, in metres per second, immediately after bounce;

v_2 is the crosshead velocity, in metres per second, at the moment when the specimen breaks;

E is the energy, in joules, read from the pendulum dial;

e is the energy contribution, in joules, of the crosshead, i.e. the bounce-correction factor to be added to the pendulum reading.

Once the crosshead has rebounded, the momentum of the system (in the horizontal direction) remains constant. Neglecting vertical components, the momentum equation for the impact can be written as follows:

$$MV - mv_1 = MV_2 - mv_2 \qquad \text{(B.3)}$$

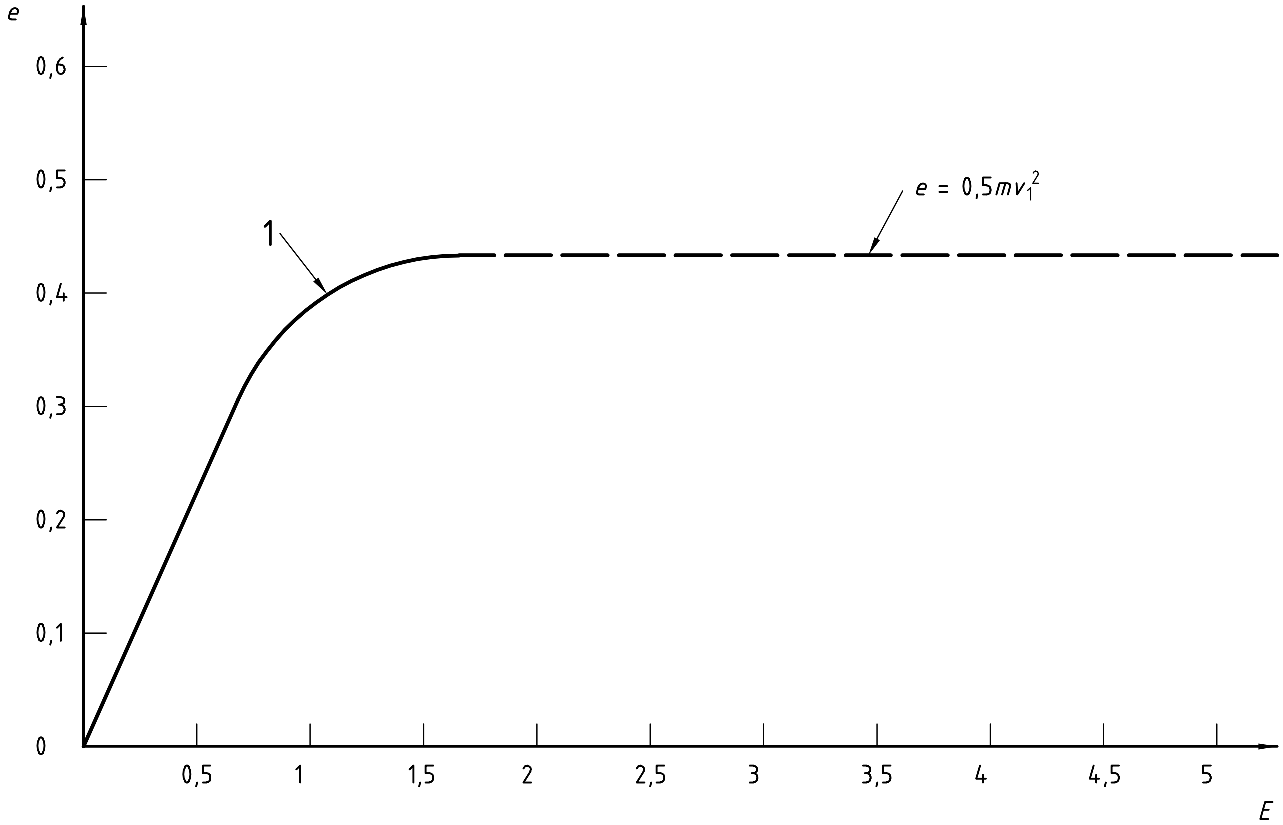
Equations (B.1), (B.2) and (B.3) can be combined to give:

$$e = \frac{1}{2} \times m \left\{ v_1^2 - \left[v_1 - \frac{M}{m} \times \left(V - \sqrt{V^2 - \frac{2 \times E}{M}} \right)^2 \right] \right\} \qquad \text{(B.4)}$$

In Equation (B.4), the crosshead velocity after bounce v_1 is the only unknown quantity. As pointed out in ASTM D 1822 [1], in a real test carried out on a specimen the initial rebound velocity of the crosshead v_1 is the same as that measured with no specimen in the pendulum. For the particular impact tester used in the procedure described in the ASTM standard mentioned above, v_1 can be determined either experimentally by photographic analysis or theoretically by the coefficient of restitution method.

If e is plotted as a function of E (for fixed values of V, M, m and v_1), e will increase from zero, pass through a maximum (equal to $0{,}5mv_1^2$) and then decrease, passing again through zero before becoming negative. The only part of this curve for which a reasonably accurate analysis has been made is the initial portion between $e = 0$ and $e = 0{,}5mv_1^2$.

Once the crosshead reverses its direction of travel, the correction becomes less clearly defined and, after it contacts the anvil a second time, the correction becomes much more difficult to determine. It is assumed, therefore, for the sake of simplicity, that once e has reached its maximum value the correction factor will remain constant at a value of $0{,}5mv_1^2$. It should be clearly recognized that the use of that portion of the curve in Figure B.1 where e is constant does not give an accurate correction. However, as E grows larger, the correction factor becomes relatively less important and no great sacrifice of overall accuracy results from the assumption that the maximum correction is $0{,}5mv_1^2$.



Key

1 Equation (B.4)

Figure B.1 — Typical correction-factor curve for single bounce of crosshead in a specimen-in-head tensile-impact machine

Bibliography

[1] ASTM D 1822-99, *Standard Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials*

ICS 83.080.01

Price based on 16 pages