INTERNATIONAL STANDARD

ISO 8256

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Plastics — Determination of tensile-impact strength

Plastiques — Détermination de la résistance au choc-traction

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Foreword

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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.

International Standard ISO 8256 was prepared by Technical Committee ISO/TC 61, *Plastics*.

Annexes A and B form an integral part of this International Standard. Annex C is for information only.

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Plastics — Determination of tensile-impact strength

1 Scope

1.1 This International Standard specifies two methods for the determination of the energy required to rupture test specimens of plastics under a specified tensile-impact velocity. The tests can be described as tensile tests at comparatively high rates of straining. These methods can be used for materials too flexible or too thin to be tested with impact tests conforming to ISO 179 and ISO 180, and for more rigid materials. Different parameters are specified depending on the type of test specimen (see 6.1 and figure 3).

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. The response of plastics to comparatively high rates of straining is useful to describe, for example, the behaviour of materials when subjected to weathering or thermal ageing, as well as to assess their properties under corresponding service conditions.

1.3 These methods are applicable to specimens prepared from moulding materials or to specimens taken from finished or semi-finished products (for example mouldings, films, laminates or extruded or cast sheets). The methods are suitable for production control as well as for quality control. Test results gained on test specimens obtained 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.

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. 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 testing at different temperatures.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 179:1982, *Plastics — Determination of Charpy impact strength of rigid materials.*

ISO 180:1982, *Plastics — Determination of Izod impact strength of rigid materials.*

ISO 291:1977, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 293:1986, *Plastics — Compression moulding test specimens of thermoplastic materials.*

ISO 294:1975, *Plastics — Injection moulding test specimens of thermoplastic materials.*

ISO 295:1974, *Plastics — Compression moulding test specimens of thermosetting materials.*

ISO 1268:1974, *Plastics — Preparation of glass fibre reinforced, resin bonded, low-pressure laminated plates or panels for test purposes.*

ISO 2557-1:1989, *Plastics — Amorphous thermoplastics — Preparation of test specimens with a specified maximum reversion — Part 1: Bars.*

ISO 2557-2:1986, *Plastics — Amorphous thermoplastics — Preparation of test specimens with a specified reversion — Part 2: Plates.*

ISO 2818:1980, *Plastics — Preparation of test specimens by machining.*

ISO 3167:1983, *Plastics — Preparation and use of multipurpose test specimens.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 tensile-impact strength of unnotched specimens: The energy absorbed in breaking an unnotched specimen under specified conditions, referred to the original cross-sectional area of the specimen.

It is expressed in kilojoules per square metre (kJ/m²).

3.2 tensile-impact strength of notched specimens: The energy absorbed in breaking a notched specimen under specified conditions, referred to the original cross-sectional area of the specimen at the notch.

It is expressed in kilojoules per square metre (kJ/m²).

4 Principle

The energy utilized in this test method is delivered by a single swing of the pendulum of a tensile-impact machine. 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 or bounce the crosshead.

The specimen is impacted at the bottom of the swing of the pendulum. The specimen is horizontal at 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 crosshead may be either mounted stationary on the support frame (method A) or carried downward together with the pendulum (method B).

5 Apparatus

5.1 Test machine

5.1.1 The test machine shall be the pendulum type and shall be of rigid construction. It shall be capable of measuring the impact energy expended in breaking a test specimen. The value of the impact energy shall be taken as equal to the difference between the initial potential energy in the pendulum and the energy remaining in the pendulum after breaking the test specimen. The energy reading shall be accurately corrected for friction and air-resistance losses and for scale errors.

5.1.2 The machine shall have the characteristics shown in table 1. The frictional loss shall be periodically checked.

NOTE 1 In order to apply the test to the full range of materials specified in 1.3, it is necessary to use more than one machine or to use a set of interchangeable pendulums. It is not advisable to compare results obtained with different pendulums.

5.1.3 The machine shall be securely fixed to a foundation having a mass of at least 20 times that of the heaviest pendulum in use. It shall be adjusted so that the orientations of the striker and supports are as specified in 5.2 and 5.3.

5.1.4 The distance between the axis of rotation and the centre of impact of the pendulum shall be within ± 1 % of the distance from the axis of rotation to the centre of the test specimen.

5.1.5 The dial, or other indicator of the energy consumed, shall be capable of being read to an accuracy of ± 1 % of full-scale deflection.

5.1.6 The machine shall be of the type shown schematically in figure 1 for method A, or of the type shown in figure 2 for method B.

5.2 Pendulum

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 Accurate means shall be available to determine and minimize energy losses due to windage and friction (see annex B).

5.3 Crosshead

5.3.1 The crosshead, which acts as a specimen clamp for method A, shall be made from a material which guarantees a substantially inelastic impact (e.g. aluminium).

The mass of the crosshead shall be selected from the values given in table 1.

Table 1 — Characteristics of pendulum impact-testing machine

Initial potential energy J	Velocity at impact m/s	Maximum permissible frictional loss %	Crosshead mass[1)] Method A g	Crosshead mass[1)] Method B g
2,0	2,6 to 3,2	1	15 ± 1 or 30 ± 1	15 ± 1
4,0	2,6 to 3,2	0,5	15 ± 1 or 30 ± 1	15 ± 1
7,5	3,4 to 4,1	0,5	30 ± 1 or 60 ± 1	30 ± 1
15,0	3,4 to 4,1	0,5	30 ± 1 or 60 ± 1	120 ± 1
25,0	3,4 to 4,1	0,5	60 ± 1 or 120 ± 1	120 ± 1
50,0	3,4 to 4,1	0,5	60 ± 1 or 120 ± 1	120 ± 1

1) For method A, use the lighter crosshead wherever possible.

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

5.4 Clamping devices/jaws

5.4.1 For specimen types 1, 2, 3 and 4 (see table 2 and figure 3), the surfaces between which the specimen is clamped shall be clamped such that there is no slippage when the blow is struck. The same applies to the jaw faces of the clamping device attached to the frame. The clamping device shall be such as to ensure that it does not contribute to failure of the specimen.

Jaws may have file-like serrations, and the size of serrations shall be selected, according to experience, to suit the hardness and toughness of the specimen material and the thickness of the specimen. The edges of the serrated jaws in close proximity to the test region shall have a radius such that they cut across the edges of the first serrations.

5.4.2 For specimen type 5, held only by embedding, a notched pair of jaws with different heights is necessary. The pair of jaws chosen for the test shall be the one whose height is greater than the thickness of the specimen but lower than 120 % of its thickness.

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. For measuring the thickness of film and sheeting with thicknesses below 1 mm, use an instrument reading to an accuracy of not less than 5 % of the nominal thickness. 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 Dimensions and notches

Five types of test specimen, as specified in table 2 and shown in figure 3, may be used. For method A, the preferred specimen types are type 1 (notched) and type 3 (unnotched), but type 2, 4 or 5 may also be used if required. For method B, the preferred specimen types are type 2 and type 4.

The test result depends on the type of specimen used and its thickness. For reproducible results, or in case of dispute, therefore, the type of test specimen and its 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. 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 use shall be made of ISO 179 or ISO 180.

NOTE 2 Specimen type 1 can be prepared from the multi-purpose test specimen described in ISO 3167.

6.2 Preparation

6.2.1 Moulding or 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, compression or injection moulded from the material in accordance with ISO 293, ISO 294, ISO 295, ISO 2557-1 or ISO 2557-2 as appropriate, or machined in accordance with ISO 2818 from sheet that has been compression or injection moulded from the compound.

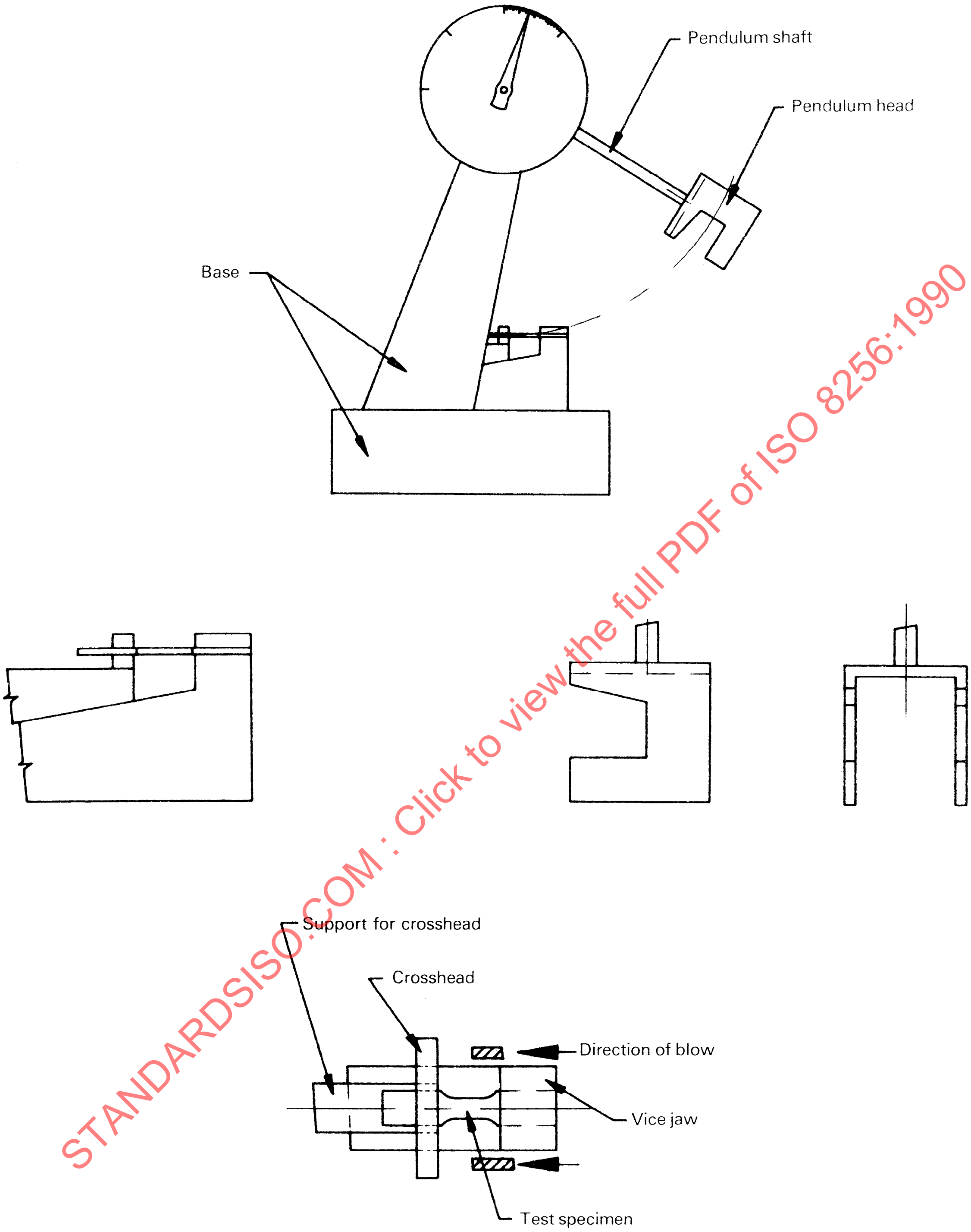

Figure 1 — Diagram showing relationship of pendulum to specimen clamps for method A

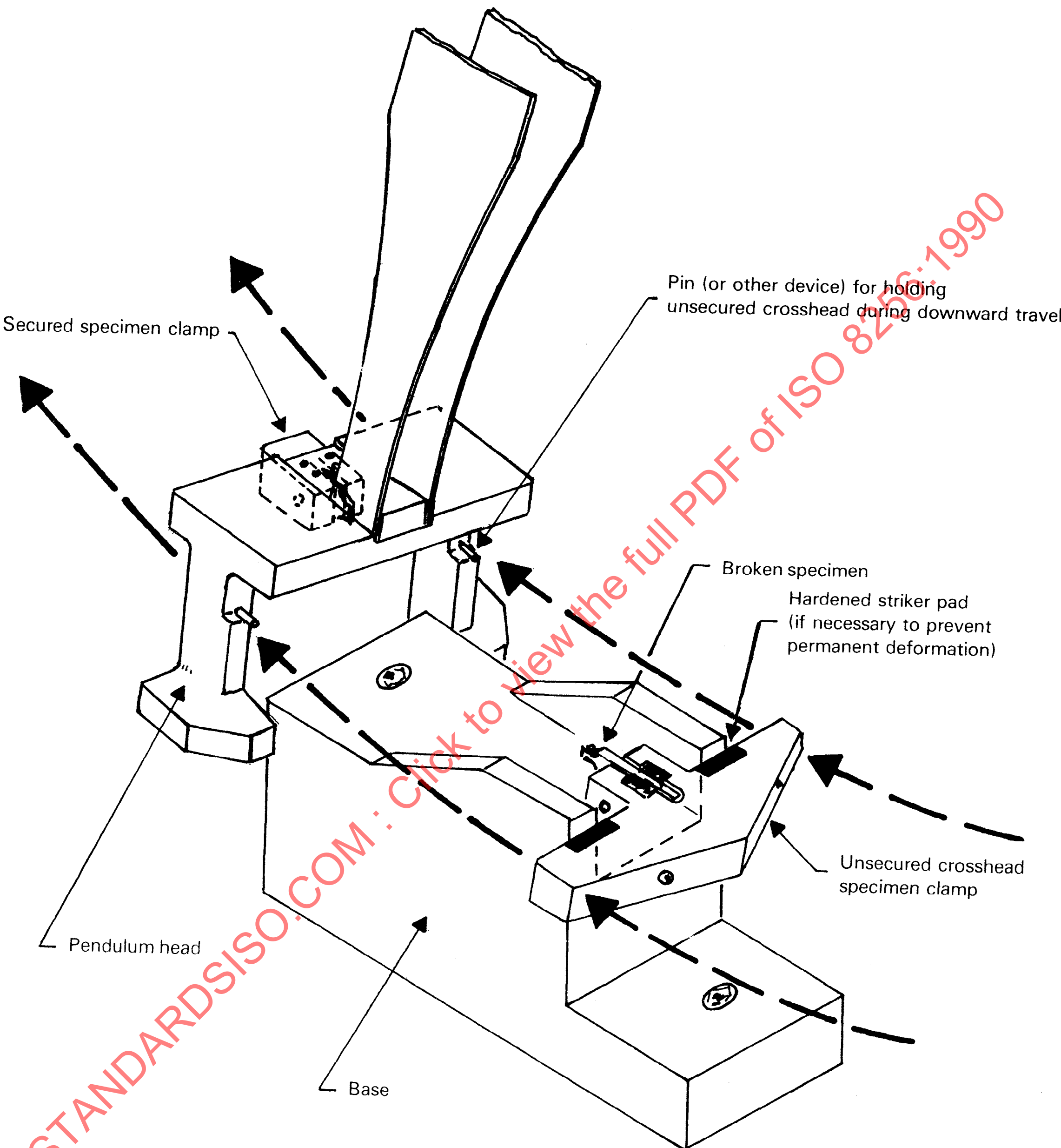

Figure 2 — Diagram showing relationship of pendulum to specimen clamps for method B after specimen rupture

Table 2 — Specimen types and dimensions and distances between supports (see also figure 3)

Dimensions in millimetres

Specimen type	Length, l	Width, b	Preferred value of dimension, x	Preferred value for l_o	Free length between grips, l_e	Radius of curvature, r
1[1)]	80 ± 2	10 ± 0,5	6 ± 0,2	—	30 ± 2	—
2	60 ± 1	10 ± 0,2	3 ± 0,05	10 ± 0,2	25 ± 2	10 ± 1
3	80 ± 2	15 ± 0,5	10 ± 0,5	10 ± 0,2	30 ± 2	20 ± 1
4	60 ± 1	10 ± 0,2	3 ± 0,1	—	25 ± 2	15 ± 1
5[2)]	80 ± 2	15 ± 0,5	5 ± 0,5	10 ± 0,2	50 ± 0,5	20 ± 1

1) Notch angle is 45° ± 1°, radius of notch 1,0 mm ± 0,02 mm.

2) For type 5: b' = 23 mm ± 2 mm r' = 6 mm ± 0,5 mm l' = 11 mm ± 1 mm

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 ISO 1268, and specimens shall be machined in accordance with ISO 2818.

6.2.4 Thin films

For thin films, the use of multi-layer specimens is recommended. To prepare such specimens, the necessary number of layers of film shall be fixed in place before stamping, e.g. by means of adhesive tapes applied over a distance of 30 mm from each end. The adhesive tapes are used for thin films to hold the specimens together, at the ends, before and after stamping. In other cases, double-faced tape may be used between each layer of film. Film specimens shall be free from scratches, and each layer shall be free from either tension or slackness relative to other layers in the specimen.

6.3 Notching of specimens (type 1)

6.3.1 Notches 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 ± 0,02 mm, its angle 45° ± 1° (see figure 3). The profile of the cutting tooth (teeth) 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 3. The two lines drawn perpendicular to the length direction of the specimen through the apex of each notch shall be within 0,02 mm of each other. Particular attention shall be given to the accuracy of the dimension x (see table 2).

NOTE 3 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.

6.3.3 Specimens with moulded-in notches may be used if specified in the specification for the material being tested.

NOTE 4 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.

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

6.4 Number of test specimens

6.4.1 Unless otherwise specified in the specification for the material being tested, a minimum of 10 specimens shall be tested.

6.4.2 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 inferred from a knowledge of the method of its manufacture.

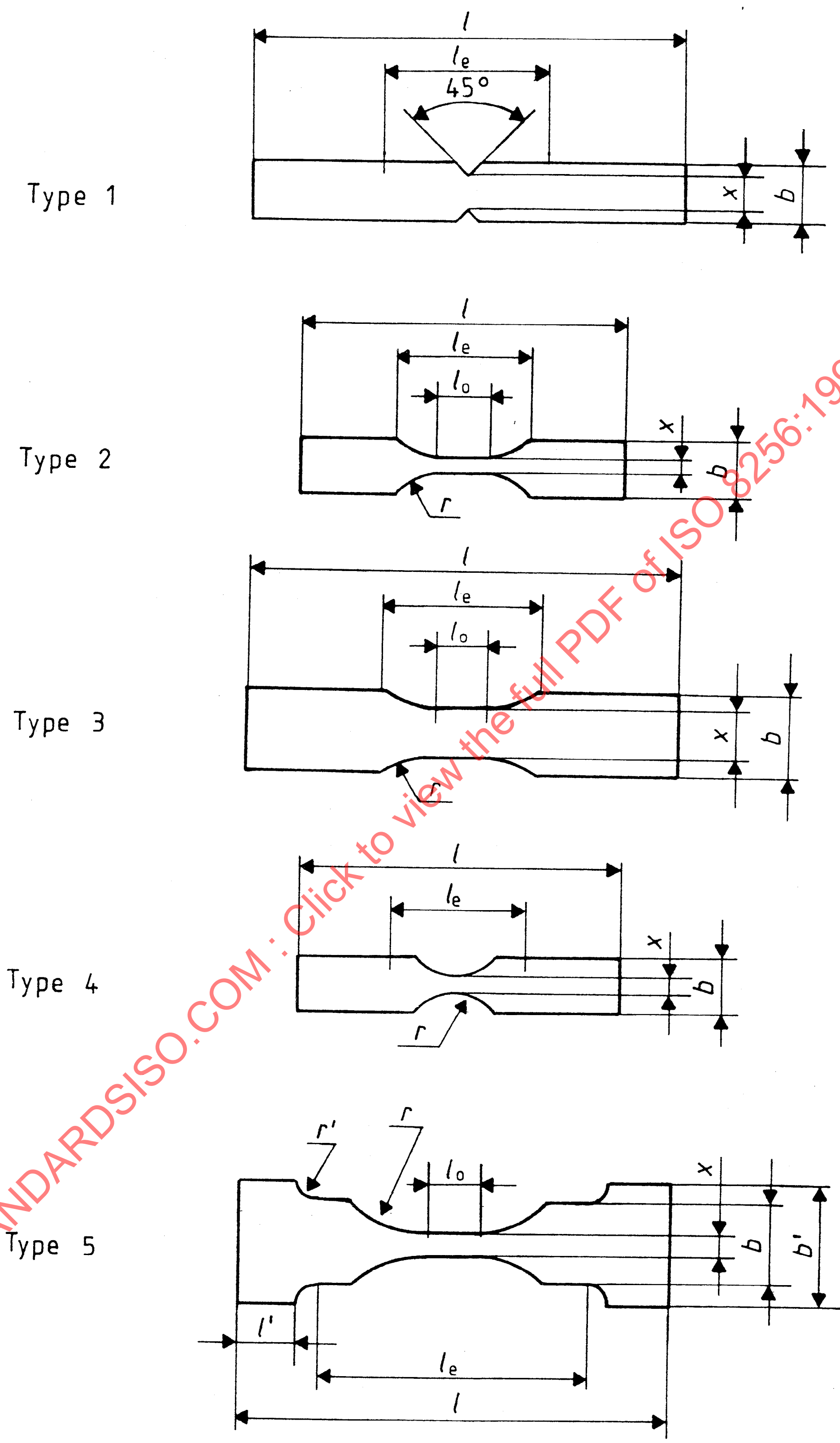

Figure 3 — Test specimens

6.5 Conditioning

Unless otherwise specified in the specification for the material being tested, the specimens shall be preconditioned and tested in accordance with ISO 291.

7 Procedure

7.1 Check that the pendulum machine is of the correct energy range and that it has the specified striking velocity (see table 1).

The selected pendulum shall consume at least 20 %, but not more than 80 %, of its stored energy in breaking the test specimen. If more than one of the pendulums described in table 1 meets these requirements, the pendulum having the higher energy shall be used.

7.2 If applicable, adjust the pointer on the energy scale so that it touches the driving pin when the pendulum is in the starting position. Carry out a blank test three times (i.e. without a specimen or crosshead in place), calculate the mean frictional loss and ensure that the mean frictional loss does not exceed the values given in table 1.

7.3 Determination of energy corrections

7.3.1 Method A — Energy correction E_q due to the plastic deformation and the kinetic energy of the crosshead (see also annex C)

The correction E_q is determined from the equation

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

$$\approx \frac{3}{2} E_{max}\mu$$

where

E_q is the energy correction due to the plastic deformation and the kinetic energy of the crosshead (see annex B or annex C for details);

E_{max} is the maximum impact energy 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 is given by the equation

$$m_p = \frac{E_{max}}{gL(1-\cos\alpha)}$$

where

g is the acceleration due to gravity;

L is the reduced length of the pendulum;

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

L is given by the equation

$$L = \frac{gT^2}{4\pi^2}$$

where T is the period of the pendulum.

If α is 160° and m_p is measured in kilograms, with E_{max} in joules and L in metres, it follows that

$$m_p = 5{,}3 \times 10^{-2} \frac{E_{max}}{L}$$

7.3.2 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 A for details.)

7.4 Measure the thickness d and 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, for example, a micrometer fitted with an anvil of width 2 mm to 3 mm and of suitable profile to fit the shape of the notch.

7.5 Lift and arrest the pendulum, and adjust the pointer in accordance with 7.2.

7.6 Insert the specimen in the holder and tighten firmly.

7.7 Carefully release the pendulum. Read from the scale the impact energy E_s absorbed by the specimen and apply corrections for frictional losses as necessary (see 7.2).

7.8 If the resulting corrected tensile-impact energy is below 20 % of the capacity of the 2-joule pendulum (see table 1), multi-layer specimens prepared in accordance with 6.2.4 shall be used.

7.9 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.

7.10 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 Expression of results

In order to calculate the tensile-impact strength, the consumed energy E_s must first be corrected for the toss energy E_q.

8.1 Calculation of energy correction

8.1.1 Energy correction for method A

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

$$E_c = E_s - E_q$$

where

E_s is the consumed energy (non-corrected) in joules;

E_q is the elastic toss energy, in joules, of the crosshead, calculated as specified in 7.3.1.

8.1.2 Energy correction for method B

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

$$E_c = E_s + E_b$$

where

E_s is the consumed energy (non-corrected), in joules;

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 7.3.2 and annex A.

8.2 Calculation of tensile-impact strength

The tensile-impact strength E or the tensile-impact strength (notched) E_n, expressed in kilojoules per square metre, is calculated using the equation

$$E \text{ or } E_n = \frac{E_c}{x \cdot d} \times 10^3$$

where

E_c is the corrected impact energy, in joules, calculated in accordance with 8.1;

x is the width, in millimetres, of the narrow, parallel-sided section of the specimen or the distance between the notches (see figure 3);

d is the thickness, in millimetres, of the narrow, parallel-sided section of the specimen (or for plied film, the total thickness).

Calculate the arithmetic mean, the standard deviation and the coefficient of variation of the ten results as required.

Report all calculated values to two significant figures.

9 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 with the following revision.

10 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) the method used (A or B);

c) full identification of the material tested, including manufacturer's code, material grade and material form;

d) the type of test specimen used or the dimensions of the test specimens;

e) the method of preparing the test specimens;

f) 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;

g) details of preconditioning and the test conditions;

h) the maximum energy of the pendulum used;

i) the mass of the crosshead used;

j) the tensile-impact strength E or E_n 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) if required, the standard deviation and the coefficient of variation of the results;

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

Annex A
(normative)

Determination of bounce-correction factor

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, one must 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,

$$E = \frac{1}{2} M\left(V^2 - V_2^2\right) \qquad \text{... (A.1)}$$

and

$$e = \frac{1}{2} m\left(v_1^2 - v_2^2\right) \qquad \text{... (A.2)}$$

where

M is the mass, in kilograms, of pendulum;

m is the mass, in kilograms, of crosshead;

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

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

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

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

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

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

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

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 evaluate. 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 realised that the use of that portion of the curve in figure A.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 $0{,}5mv_1^2$.

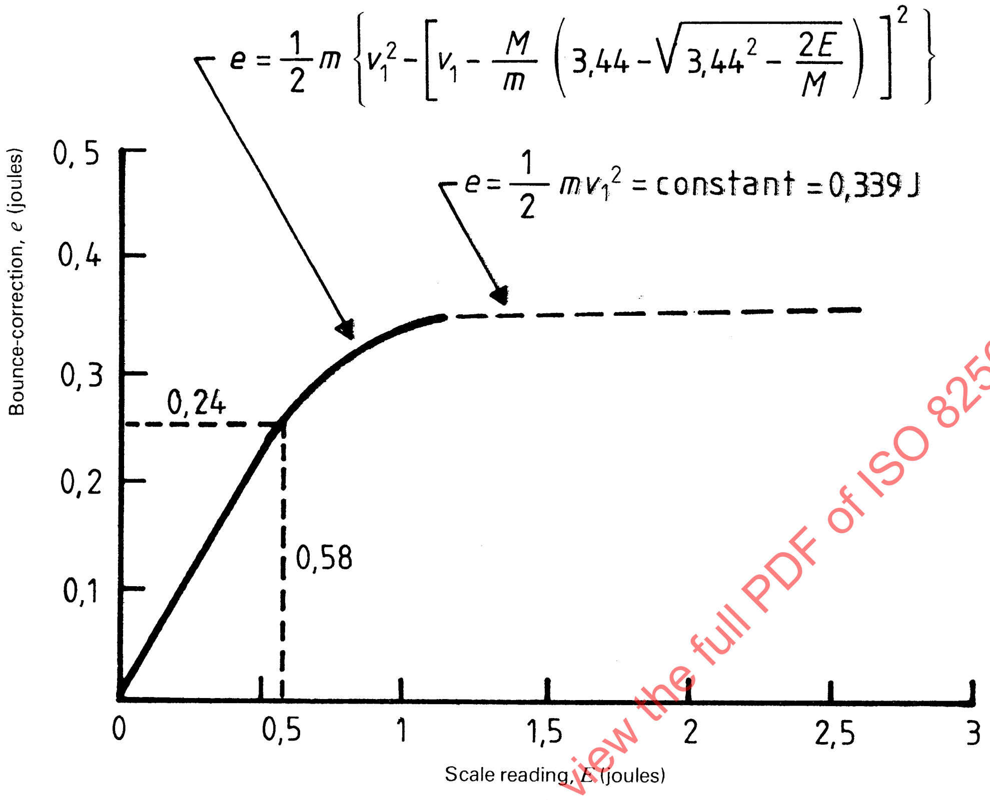

Figure A.1 — Typical correction-factor curve for single bounce of crosshead specimen-in-head tensile-impact machine (6,8 J hammer, steel crosshead)

Annex B
(normative)

Instructions for the construction and use of a windage and friction correction chart for method B

B.1 The construction and use of the chart described is based upon the assumption that the friction and windage losses are proportional to the angle through which these forces act on the pendulum. Figure B.1 shows a plot of the assumed energy loss versus the pendulum position (i.e. the angle through which the pendulum has swung) during the pendulum swing. The correction chart to be described is essentially the left-hand half of figure B.1.

B.2 Start the construction of the correction chart (figure B.2) by laying off to some convenient linear scale on the abscissa the pendulum position for the portion of the swing beyond the free-hanging position. Place the free-hanging reference point at the right-hand end of the abscissa, with the angular displacement increasing linearly to the left. The abscissa is referred to as scale C. Although angular displacement is the quantity to be represented linearly on the abscissa, this displacement is more conveniently expressed in terms of indicated energy read from the machine dial. This yields a non-linear scale C with indicated pendulum energy increasing to the right.

B.3 On the right-hand ordinate, lay off a linear scale B, starting with zero at the bottom and stopping at the maximum expected pendulum friction and windage value at the top.

B.4 On the left-hand ordinate construct a linear scale D, ranging from zero at the bottom to 1,2 times the maximum ordinate value appearing on scale B, but make the scale twice the scale used in the construction of scale B.

B.5 Adjoining scale D draw a curve OA which is the locus of the points representing equal values of the energy correction on scale D and the indicated energy on scale C. This curve is referred to as scale A and utilizes the same divisions and numbering system as the adjoining scale D.

B.6 The chart is used as follows:

B.6.1 Locate and mark on scale A the reading A obtained from the free swing of the pendulum with the pointer prepositioned on the dial in the free-hanging or maximum-indicated-energy position.

B.6.2 Locate and mark on scale B the reading B obtained after several free swings of the pendulum with the pointer pushed up close to the zero-indicated-energy position on the dial.

B.6.3 Join the two points thus obtained by a straight line.

B.6.4 From the indicated impact energy on scale C, project up to the constructed line and across to the left to obtain the correction for windage and friction from scale D.

B.6.5 Subtract this correction from the indicated impact-energy reading to obtain the energy delivered to the specimen. (See 7.7.)

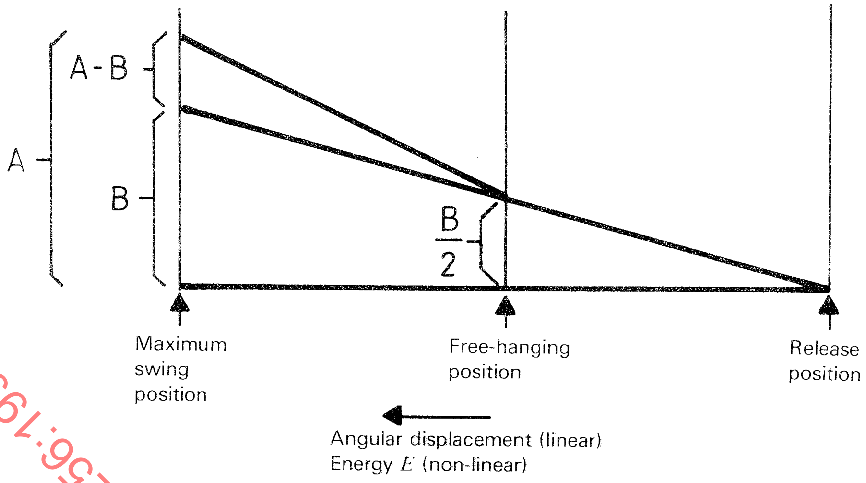

Figure B.1 — Method of construction of a windage and friction correction chart

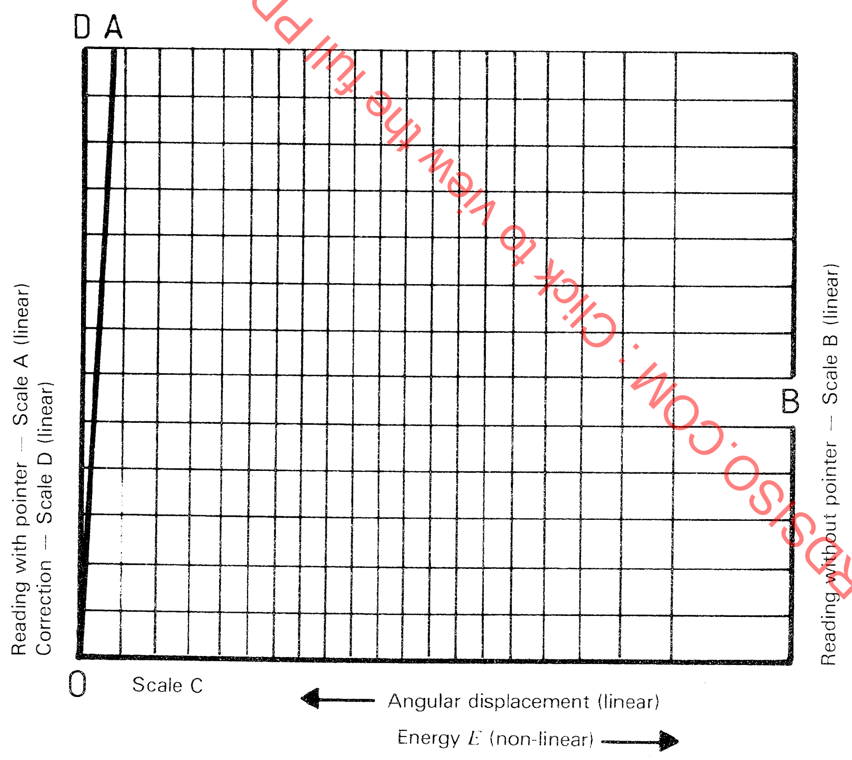

Figure B.2 — Sample windage and friction correction chart