International Standard 180

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Plastics — Determination of Izod impact strength of rigid materials

Plastiques — Détermination de la résistance au choc Izod des matières rigides

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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 developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been authorized 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 180 was developed by Technical Committee ISO/TC 61, *Plastics* and was circulated to the member bodies in July 1980.

It has been approved by the member bodies of the following countries:

Australia	Iran	South Africa, Rep. of
Brazil	Ireland	Spain
Canada	Israel	Sweden
Czechoslovakia	Italy	Switzerland
Egypt, Arab Rep. of	Korea, Rep. of	United Kingdom
Finland	Mexico	USA
Germany, F.R.	Netherlands	USSR
Hungary	Poland	
India	Romania	

The member bodies of the following countries expressed disapproval of the document on technical grounds:

Austria
China
France

This International Standard cancels and replaces ISO Recommendation R 180-1961 of which it constitutes a technical revision.

Plastics — Determination of Izod impact strength of rigid materials

1 Scope and field of application

1.1 This International Standard specifies a method for the determination of the Izod impact strength of rigid plastics.

Different test parameters are specified according to the type of test specimen and the type of notch (see 6.1, table 3 and figures 2 and 3).

1.2 The method is used for investigating the behaviour of specified specimens under specified impact stresses, and for estimating the brittleness or the toughness of specimens within the limitations inherent in the test conditions.

1.3 It is applicable, *inter alia*, to the following materials:

— rigid thermoplastic moulding and extrusion materials, including filled and reinforced compounds, and rigid thermoplastic sheet;

— rigid thermosetting moulding materials, including filled and reinforced compounds;

— rigid thermosetting sheet, including laminates;

— fibre reinforced materials (composites), incorporating mat, woven fabric, woven rovings, chopped strands, chopped rovings, rovings, and milled fibres, including pre-impregnated materials (prepregs);

— unidirectional fibre reinforced materials (composites), including pre-impregnated materials (prepregs).

NOTE — The use of notched specimens is unsuitable for some reinforced plastics. The method may not be suitable for foamed materials.

1.4 The method is applied to specimens prepared from moulding materials or to specimens taken from finished and semi-finished products (for example mouldings, laminates, extruded or cast sheets). The method is suitable for production control as well as for the acceptance and rejection of materials according to specifications for moulding materials and products.

1.5 The results obtained by testing specimens of different dimensions and specimens cut from moulded products may not necessarily be the same.

1.6 The method should not be used 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 specimens prepared under different conditions, varying the notch radius, and testing at different temperatures.

2 References

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

ISO 293, *Plastics — Recommended practice for compression moulding test specimens of thermoplastic materials.*[1)]

ISO 294, *Plastics — Recommended practice for injection moulding test specimens of thermoplastic materials.*[2)]

ISO 295, *Plastics — Recommended practice for compression moulding test specimens of thermosetting materials.*[3)]

ISO 1268, *Plastics — Recommended practice for preparation of glass fibre reinforced, resin bonded, low pressure laminated plates or panels for test purposes.*[4)]

ISO 2557, *Plastics — Amorphous thermoplastic moulding materials — Preparation of test specimens with a defined level of shrinkage —*

Part 1: Test specimens in the form of parallelepipedic bars (Injection moulding and compression moulding).[5)]

Part 2: Test specimens in the form of rectangular plates (Injection moulding).[5)]

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

ISO 3167, *Plastics — Recommended practice for preparation and use of multipurpose specimens of thermoplastic materials.*[6)]

1) At present at the stage of draft. (Revision of ISO 293-1974.)
2) At present at the stage of draft. (Revision of ISO 294-1975.)
3) At present at the stage of draft. (Revision of ISO 295-1974.)
4) At present at the stage of draft. (Revision of ISO 1268-1974.)
5) At present at the stage of draft. (Revisions of ISO 2557/1-1976 and ISO 2557/2-1979.)
6) At present at the stage of draft. (Revision of ISO 3167-1975.)

3 Definitions

3.1 Izod impact strength of notched specimens: The impact energy absorbed in breaking a notched specimen, referred to the original cross-sectional area of the specimen at the notch.

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

3.2 Izod impact strength of reversed notch specimens: The impact energy absorbed in breaking a reversed notch specimen, referred to the original cross-sectional area of the specimen at the notch.

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

NOTE — The reversed notch test gives an indication of the Izod impact strength of unnotched specimens.

3.3 relative impact strength: The ratio of the impact strengths of notched to reversed notch specimens with the same notch base radius, or of notched specimens with different notch base radii, for test specimens of the same type.

4 Principle

The test specimen, supported as a vertical cantilever beam, is broken by a single swing of a pendulum, with the line of impact at a fixed distance from the specimen clamp and from the centre line of the notch.

For determination of the Izod impact strength of notched specimens, the pendulum strikes the face containing the notch. For determination of the Izod impact strength of reversed notch specimens, the pendulum strikes the face opposite to that containing the notch.

5 Apparatus

5.1 Testing machine

5.1.1 The testing machine shall be of the pendulum type[1)] and shall be of rigid construction. It shall be capable of measuring the impact energy expended in breaking a test specimen, the value of which 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 scale shall be accurately corrected for friction and air-resistance losses and scale errors.

5.1.2 The machine shall have the characteristics shown in table 1 (see the notes). These characteristics shall be periodically checked.

NOTES

1 In order to apply the test to the full range of materials specified in 1.3, it may be 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.

2 Other pendulums may be used, if necessary, by agreement between the interested parties.

5.1.3 The machine shall be securely fixed to a foundation having a mass of at least 40 times that of the heaviest pendulum in use. It shall be adjusted so that the orientations of the striker and vice are as specified in 5.1.4 and 5.1.6.

5.1.4 The striking edge of the pendulum shall be of hardened steel and shall have a cylindrical surface having a radius of curvature of 0,8 ± 0,2 mm, with its axis horizontal and perpendicular to the plane of motion of the pendulum. It shall be aligned so that it makes contact across the full width of rectangular test specimens. The line of contact shall be within ± 2° of perpendicular to the longitudinal axis of the test specimen.

5.1.5 The distance between the axis of rotation and the centre of percussion of the pendulum shall be within ± 1 % of the distance from the axis of rotation to the point of contact of the striking edge with the test specimen.

5.1.6 The test specimen support shall comprise a vice consisting of a fixed and movable jaw. The clamping surfaces of the jaws shall be parallel to within 0,025 mm. The vice shall be so arranged that it holds the test specimen vertically in respect to its long axis and at right angles to the top plane of the vice (see figure 1). The top edges of the vice jaws shall have radii of 0,2 ± 0,1 mm. Means shall be provided to ensure that when the test specimen is clamped in the vice, the top plane of the vice is within 0,2 mm of the plane bisecting the angle of the notch.

Table 1 — Characteristics of pendulum impact testing machines

Impact energy	Velocity at impact	Maximum permissible frictional loss	Permissible error after correction
J	m/s	%	J
1,0	3,5 (± 10 %)	2	0,01
2,75	3,5 (± 10 %)	1	0,01
5,5	3,5 (± 10 %)	0,5	0,02
11,0	3,5 (± 10 %)	0,5	0,05
22,0	3,5 (± 10 %)	0,5	0,10

1) Falling weight type machines may be used if they can be shown to give the same results as pendulum type machines.

The vice shall be positioned so that the test specimen is central, to within ± 0,5 mm, to the striking edge and so that the centre of the striking edge is 22,0 ± 0,2 mm above the top plane of the vice (see figure 1). The vice shall be designed to prevent the clamped portion of the test specimen from moving during the clamping or testing operations.

5.1.7 Some plastics are sensitive to clamping pressure. When testing such materials, some means of standardizing the clamping force shall be used and the clamping force shall be recorded in the test report. One way of measuring clamping force is to use a calibrated torque wrench on the vice clamping screw.

5.2 Micrometers and gauges

Micrometers and gauges suitable for measuring the essential dimensions of test specimens to an accuracy of 0,02 mm are required.

6 Test specimens

6.1 Dimensions and notches

6.1.1 Four types of test specimen with two different types of notch may be used as specified in tables 2 and 3, and shown in figures 2 and 3.

The preferred type of test specimen is type 1, and the preferred type of notch is type A. However, the type of specimen and the type of notch will be indicated in the specification, if any, for the material being tested. Test specimen types 2, 3 and 4 differ only in width (dimension x). The type of notch will also depend on the information required from the test.

NOTES

1 It has been found necessary to retain four types of test specimen to cover current national usage, but it is hoped that more widespread adoption of the type 1 specimen will allow the number to be reduced in the future.

2 Notch type A has been adopted as the preferred type for the determination of Izod impact strength. Carrying out tests with both notch types A and B (i.e. at two well-defined notch base radii) over a range of temperatures may provide valuable information on the variation of notch sensitivity of the material with temperature (ductile/brittle transitions).

6.1.2 Specimens taken from sheet thicker than 12,7 mm shall be milled uniformly on both surfaces to achieve a thickness 12,7 ± 0,2 mm.

When testing sheet materials in the edgewise direction, test specimens shall be cut so that the thickness of the sheet is dimension x (see figure 2). When testing sheet materials in the flatwise direction, the test specimens shall be cut so that the thickness of the sheet is dimension y (see figures 2 to 5).

Table 2 — Specimen types and dimensions [1)]

Dimensions in millimetres

Specimen type	Length, l	Dimension y	Preferred value of dimension x
1	80,0 ± 2	10,0 ± 0,2	4,0 ± 0,2
2	63,5 ± 2	12,7 ± 0,2	12,7 ± 0,5
3	63,5 ± 2	12,7 ± 0,2	6,4 ± 0,3
4	63,5 ± 2	12,7 ± 0,2	3,2 ± 0,2

1) Attention is drawn to the changes in the specimen type numbers and the method designation from those used in ISO/R 180.

Table 3 — Method designations, specimen types, notch types and notch dimensions [1)]

Method designation	Specimen type	Notch type	Notch dimensions, mm
ISO 180/1A	1	A	y_k = 8,0 ± 0,1
ISO 180/1B	1	B	y_k = 8,0 ± 0,1
ISO 180/1C	1	Reversed	y_k = 8,0 ± 0,1
ISO 180/2A	2	A	y_k = 10,2 ± 0,1
ISO 180/2B	2	B	y_k = 10,2 ± 0,1
ISO 180/2C	2	Reversed	y_k = 10,2 ± 0,1
ISO 180/3A	3	A	y_k = 10,2 ± 0,1
ISO 180/3B	3	B	y_k = 10,2 ± 0,1
ISO 180/3C	3	Reversed	y_k = 10,2 ± 0,1
ISO 180/4A	4	A	y_k = 10,2 ± 0,1
ISO 180/4B	4	B	y_k = 10,2 ± 0,1
ISO 180/4C	4	Reversed	y_k = 10,2 ± 0,1

1) Attention is drawn to the changes in the specimen type numbers and the method designation from those used in ISO/R 180.

6.1.3 Notches shall always be cut so that the dimension x is the length of the notch (see figures 2 and 3).

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 unless otherwise specified, specimens shall be either directly 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.

Type 1 specimens may be cut from the standard multipurpose specimen (see ISO 3167).

6.2.2 Sheets

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

6.2.3 Glass fibre reinforced resins

A panel shall be prepared from the compound in accordance with ISO 1268 and specimens shall be machined therefrom in accordance with ISO 2818.

6.2.4 Machining

The parameters of machining are specified in ISO 2818. However, additional attention shall be given to the following criteria.

The speed of machining is dependent on the material being tested and shall be such that overheating of the material is avoided; this is particularly important in the case of thermoplastic materials. If a coolant is used, it shall have no deleterious effect on the material being machined. All machined surfaces shall be free from visible flaws, scratches and other imperfections. Fine abradants may be used to achieve a smooth finish.

NOTE — When machining specimens, care should be taken to avoid skin contact with and inhalation of dust, as dust causes irritation.

6.2.5 Checking

Each specimen shall be free of twist and shall have mutually perpendicular pairs of parallel surfaces, free from scratches, pits and sink marks. The specimens shall be checked for conformity with these requirements by visual observation against straight-edges, squares and flat plates, and by measuring with micrometer calipers. Any specimen showing measurable or observable departure from one or more of these requirements shall be rejected or machined to proper size and shape before testing.

6.3 Notched specimens

6.3.1 Notches shall be machined on unnotched specimens prepared in accordance with 6.2. Notching shall be carried out on a milling machine or lathe, with a cutter which may be of the single-tooth or multi-tooth variety. The single-tooth cutter is preferred because it is more readily ground to the desired contour. The cutting edge shall be carefully ground and honed to ensure sharpness and freedom from nicks and burrs. Tools with no rake and a work relief angle of 15 to 20° have been found to be satisfactory.

The profile of the cutting tool (teeth) shall be such as to produce in the specimen, at right angles to its principal axis, a notch of the contour and depth shown in figures 2 and 3.

6.3.2 In the case of single-tooth cutters, the contour of the tip of the cutting tool may be checked instead of the contour of the notch in the specimen, if it can be shown that the two correspond or that a definitive relationship exists between them for the specific type of material being notched. There is some evidence that notches cut by the same cutter in materials of widely differing physical properties may differ in contour.

The radius of the notch base shall be 0,25 ± 0,05 mm for type A notches (see figure 2) and 1,00 ± 0,05 mm for type B notches (see figure 3).

6.3.3 A linear speed of the tip of the cutting tool of about 90 to 185 m/min, and feed rates in the range from 10 to 130 mm/min, have been found to be satisfactory for some materials. When unfamiliar materials are to be notched, it may be necessary to determine the effect of variation of the cutting speed.

6.3.4 After each 500 notches, or more often if hard abrasive materials are notched, the cutter shall be inspected for sharpness, freedom from nicks, tip radius and contour. If the radius and contour do not fall within their specified limits, the cutter shall be replaced by a newly sharpened and honed one.

A microscope with a camera lucida attachment (X 60 magnification) is suitable for checking the notch base. Relatively 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. Particular attention shall be given to the accuracy of the dimension y_k (see table 3).

6.3.5 Abradants shall not be used in preparing the notch.

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

NOTE — Specimens with moulded-in notches 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.

6.4 Number

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

6.4.2 Certain types of sheet materials may show different impact properties according to direction in the plane of the sheet. In such cases it is customary to cut 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.

6.4.3 Laminated sheet materials are normally tested in the edgewise direction. However, sheets of nominal thickness 12,7 mm or greater may, if specified, be tested in both the edgewise and flatwise directions (see 6.1.2 and figures 4 and 5).

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 10 %, 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 meet these requirements, the pendulum having the highest energy shall be used.

7.2 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 (i.e. without a specimen in place) and ensure that the total frictional losses do not exceed the values given in table 1.

7.3 Measure the dimension x of the test specimen, to the nearest 0,02 mm. Carefully measure the dimension y_k using, for example, a micrometer fitted with an anvil of width 2 to 3 mm and of suitable profile to fit the shape of the notch. Carry out two measurements, one at each end of the notch, and calculate the mean value.

7.4 Lift and arrest the pendulum, and adjust the pointer in accordance with 7.2. Place the specimen in the vice and clamp it in accordance with 5.1.6 and as shown in figure 1. For the determination of notched Izod impact strength, the notch shall be positioned on the side that is to be struck by the striking edge of the pendulum (see figure 1). For the determination of reversed notch Izod impact strength, specimens shall be positioned so that the notch is on the opposite side to that to be struck by the striking edge of the pendulum.

7.5 Carefully release the pendulum. Read from the scale the impact energy absorbed by the specimen and apply such corrections for frictional losses etc., as may be necessary.

7.6 For calculation of test results, only completely broken specimens shall be taken into consideration. Certain materials may, however, exhibit hinged breaks where the specimen remains joined by a very thin moulding skin; such breaks are acceptable.

8 Calculation and expression of results[1)]

8.1 The Izod impact strength of notched specimens, a_k, in kilojoules per square metre, is given by the formula

$$\frac{A_k}{x \cdot y_k} \times 10^3$$

where

A_k is the impact energy, in joules, absorbed by the test specimen;

x is the dimension x, in millimetres, of the test specimen;

y_k is the dimension y_k, in millimetres, of the test specimen.

8.2 The Izod impact strength of reversed notch specimens, a, in kilojoules per square metre, is given by the formula

$$\frac{A}{x \cdot y_k} \times 10^3$$

where

A is the impact energy, in joules, absorbed by the test specimen;

x is the dimension x, in millimetres, of the test specimen;

y_k is the dimension y_k, in millimetres, of the test specimen.

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

8.4 If required, calculate the relative impact strength for any two notch types as defined in 3.3, and express the result as a percentage.

8.5 Report all calculated values to two significant figures.

1) Attention is drawn to the change in the method of expression of results from that used in ISO/R 180.

9 Test report

The test report shall include the following information:

a) a reference to this International Standard;

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

c) the designation of the test method used (see table 3);

d) the type or dimensions of test specimens used;

e) the type of notch used;

f) the method of preparing the test specimens;

g) the direction of testing, i.e. whether in the 'flatwise' or 'edgewise' direction;

h) for sheets, the thickness of the sheet and, if applicable, the direction of the major axes of the specimens in relation to some feature of the sheet;

j) details of preconditioning and the test conditions;

k) the maximum energy of the pendulum or apparatus used;

m) the clamping pressure, if applicable (see 5.1.7);

n) the impact strength of the material, reported as the arithmetic mean of the results on notched and/or reversed notched test specimens, and/or relative impact strength, as applicable;

p) the individual test results;

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

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

s) if required, the relative impact strength for two notch types.

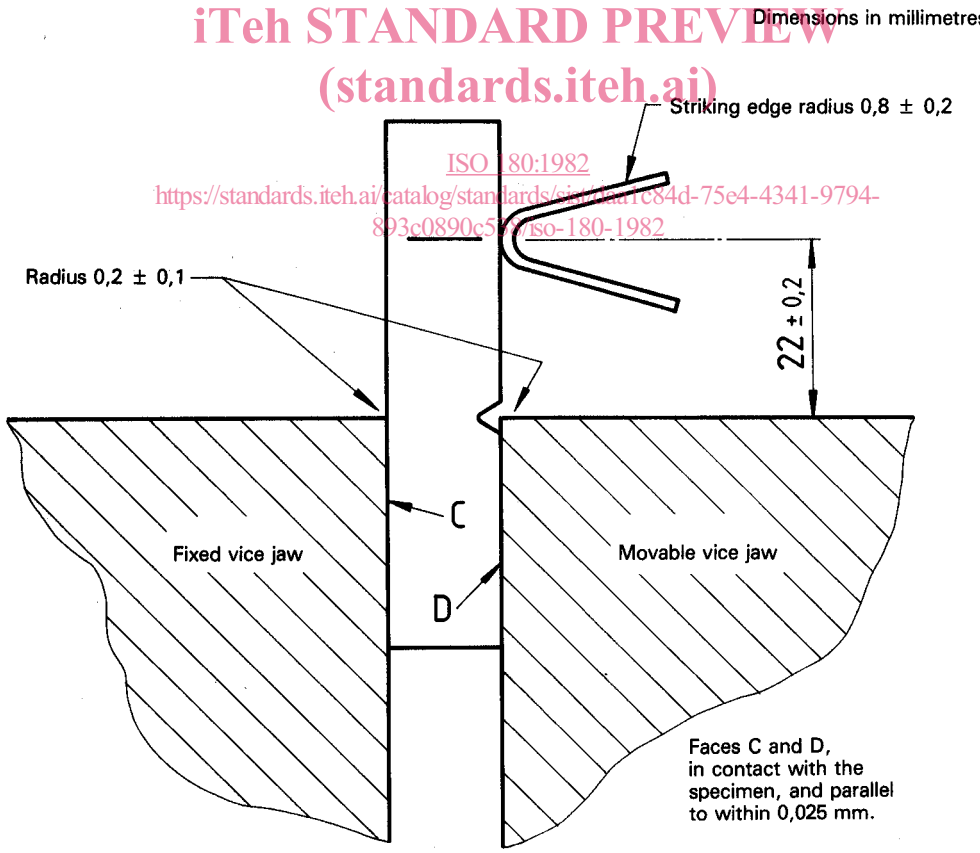

Figure 1 — Vice support and test specimen (notch and striking edge shown in normal position)

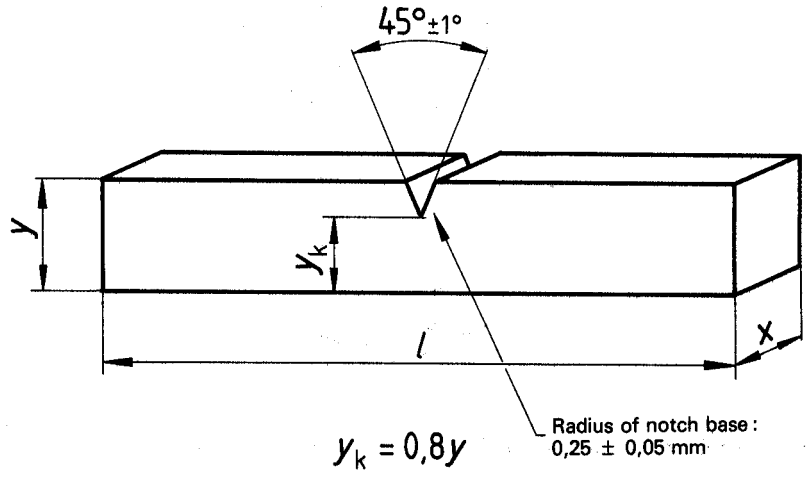

Figure 2 — Type A notch

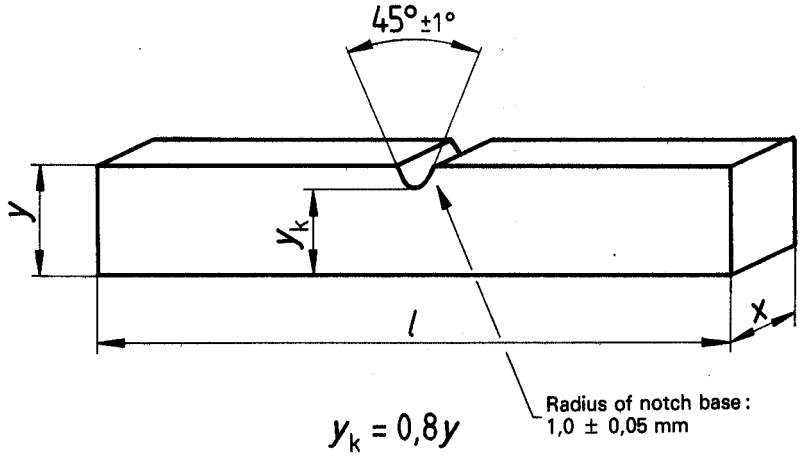

Figure 3 — Type B notch