INTERNATIONAL STANDARD

ISO 180

Second edition
1993-05-15

Plastics — Determination of Izod impact strength

Plastiques — Détermination de la résistance au choc Izod

Reference number
ISO 180:1993(E)

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.

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 180 was prepared by Technical Committee ISO/TC 61, *Plastics*, Sub-Committee SC 2, *Mechanical properties*.

This second edition cancels and replaces the first edition (ISO 180:1982), which has been revised in the following ways.

— The recommended specimen types for testing moulding materials are reduced to one only, which can be taken from the central part of the multipurpose test specimen complying with ISO 3167 by simple machining.

— Instead of testing in a "reversed-notch" configuration, the use of unnotched specimens is recommended.

— The designations of sizes are harmonized to those of a great number of other International Standards for testing plastics, in accordance with ISO 31.

— The method designations are changed and fitted to the modifications described above.

Annex A forms an integral part of this International Standard.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Plastics — Determination of Izod impact strength

1 Scope

1.1 This International Standard specifies a method for determining the Izod impact strength of plastics under defined conditions. A number of different types of specimen and test configurations are defined. Different test parameters are specified according to the type of material, the type of test specimen and the type of notch.

1.2 The method is used to investigate the behaviour of specified types of specimen under the impact conditions defined and for estimating the brittleness or toughness of specimens within the limitations inherent in the test conditions.

1.3 The method is suitable for use with the following range of materials:

— rigid thermoplastics moulding and extrusion materials, including filled and reinforced compounds in addition to unfilled types; rigid thermoplastics sheet;

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

— fibre-reinforced thermoset and thermoplastics composites incorporating unidirectional or non-unidirectional reinforcements such as mat, woven fabrics, woven rovings, chopped strands, combination and hybrid reinforcements, rovings and milled fibres; sheet made from pre-impregnated materials (prepregs);

— thermotropic liquid-crystal polymers.

The method is not normally suitable for use with rigid cellular materials and sandwich structures containing cellular material. Also, notched specimens are not normally used for long-fibre-reinforced composites or for thermotropic liquid-crystal polymers.

1.4 The method is adapted to the use of specimens which may be either moulded to the chosen dimensions, machined from the central portion of a standard multipurpose test specimen (see ISO 3167) or machined from finished and semifinished products such as mouldings, laminates and extruded or cast sheet.

1.5 The method specifies preferred dimensions for the test specimen. Tests which are carried out on specimens of different dimensions and notches, or on specimens which are prepared under different conditions may produce results which are not comparable. Other factors, such as the energy capacity of the pendulum, its impact velocity and the conditioning of the specimens can also influence the results. Consequently, when comparative data are required, these factors must be carefully controlled and recorded.

1.6 The method should not be used as a source of data for design calculations of components. Information on the typical behaviour of a material can be obtained, however, by testing at different temperatures, by varying the notch radius and/or the thickness and by testing specimens prepared under different conditions.

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

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

ISO 294:—[1], *Plastics — Injection moulding of test specimens of thermoplastic materials.*

ISO 295:1991, *Plastics — Compression moulding of 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 2602:1980, *Statistical interpretation of test results — Estimation of the mean — Confidence interval.*

ISO 2818:—[2], *Plastics — Preparation of test specimens by machining.*

ISO 3167:—[3], *Plastics — Multipurpose test specimens.*

3 Definitions

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

3.1 Izod impact strength of unnotched specimens, a_{iU}: Impact energy absorbed in breaking an unnotched specimen, referred to the original cross-sectional area of the specimen.

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

3.2 Izod impact strength of notched specimens, a_{iN}: Impact energy absorbed in breaking a notched specimen, referred to the original cross-sectional area of the specimen at the notch, the pendulum striking the face containing the notch.

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

3.3 Izod impact strength of reversed-notch specimens, a_{iR}: Impact energy absorbed in breaking a reversed-notch specimen, referred to the original cross-sectional area of the specimen at the notch, the pendulum striking the face opposite the notch.

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

3.4 parallel impact (p) (for laminar reinforced plastics): Direction of blow parallel to the laminate plane of sheet materials. The blow direction in the Izod test is "edgewise" (e) (see figure 1, "edgewise parallel").

3.5 normal impact (n) (for laminar reinforced plastics): Direction of blow normal to the laminate plane of sheet materials (see figure 1, "edgewise normal").

NOTE 1 This kind of impact is not used with the Izod test, but is indicated only for clarifying the designation system.

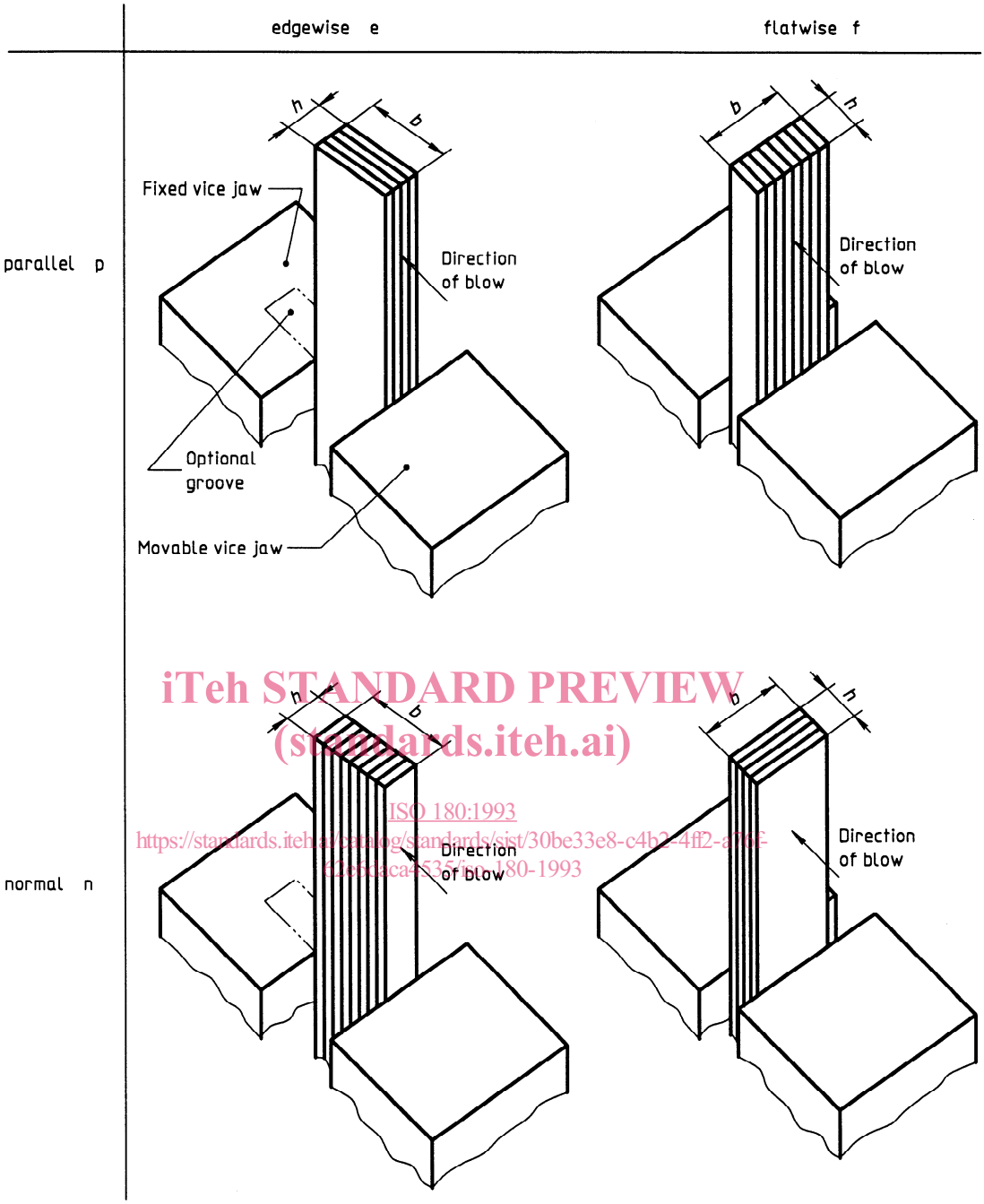
4 Principle

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, in the case of notched specimens, from the centreline of the notch (see figure 2).

1) To be published. (Revision of ISO 294:1975)

2) To be published. (Revision of ISO 2818:1980)

3) To be published. (Revision of ISO 3167:1983)



Direction of blow with respect to specimen thickness h and specimen width b: edgewise (e) and flatwise (f); with respect to the laminate plane: parallel (p) and normal (n).

The usual Izod test is edgewise parallel. When $h = b$, then parallel as well as normal can be tested.

Figure 1 — Scheme of designations describing the direction of blow

5 Apparatus

5.1 Testing machine

5.1.1 The testing machine shall be of the pendulum type and shall be of rigid construction. It shall be capable of measuring the impact energy, W, absorbed in breaking a test specimen. The value of this energy is defined as the difference between the initial energy, E, of the pendulum and the energy remaining in the pendulum after breaking the test specimen. The energy shall be corrected for losses due to friction and air resistance (see table 1 and 7.4).

5.1.2 The machine shall have the characteristics shown in table 1.

In order to apply the test to the full range of materials specified in 1.3, it is necessary to use a set of interchangeable pendulums (see 7.3). It is not advisable to compare results obtained with different pendulums. The frictional losses shall be periodically checked.

NOTE 2 Pendulums with energies other than those given in table 1 are permitted, but it is planned to withdraw this option at the next revision.

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

Table 1 — Characteristics of pendulum impact testing machines

Energy E (nominal) J	**Velocity at impact** v_o m/s	**Maximum permissible frictional loss without specimen** J	**Permissible error[1] after correction with specimen** J
1,0	3,5 (± 10 %)	0,02	0,01
2,75		0,03	0,01
5,5		0,03	0,02
11,0		0,05	0,05
22,0		0,10	0,10

1) The permissible error shall not be exceeded over the 10 % to 80 % range of the pendulum capacity.

Dimensions en millimètres

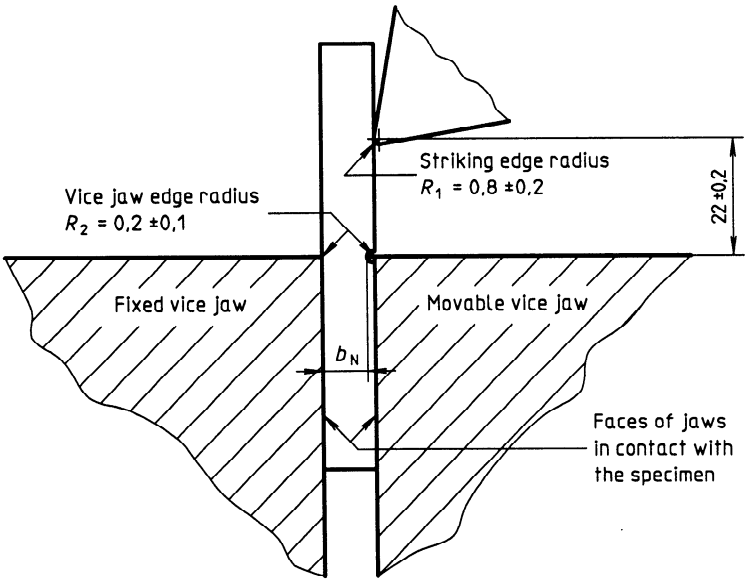


Figure 2 — Vice support, test specimen and striking edge shown at impact of notched specimen

5.1.4 The striking edge of the pendulum shall be hardened steel with a cylindrical surface having a radius of curvature of $R_1 = 0{,}8$ mm $\pm$ 0,2 mm, with its axis horizontal and perpendicular to the plane of motion of the pendulum. It shall be aligned so that it contacts the full width or thickness of rectangular test specimens. The line of contact shall be perpendicular within $\pm$ 2° to the longitudinal axis of the test specimen.

5.1.5 The distance between the axis of rotation and the point of impact shall be within $\pm$ 1 % of the pendulum length L_P.

NOTE 3 The pendulum length L_P, in metres, may be determined experimentally from the period of small amplitude oscillations of the pendulum by means of the following equation:

$$L_P = \frac{g_n}{4\pi^2} \times T^2 \qquad \ldots (1)$$

where

g_n is the standard acceleration of free fall, in metres per second squared (9,81 m/s^2);

T is the period, in seconds, of a single complete swing (to and fro) determined from at least 50 consecutive and uninterrupted swings (known to an accuracy of one part in two thousand). The angle of swing shall be less than 5° to each side of the centre.

5.1.6 The test specimen support shall comprise a vice consisting of a fixed and a moveable jaw. The clamping surfaces of the jaws shall be parallel to within 0,025 mm. The vice shall be arranged to hold the test specimen vertically with respect to its long axis and at right angles to the top plane of the vice (see figure 2). The top edges of the vice jaws shall have radii $R_2 = 0{,}2$ mm $\pm$ 0,1 mm.

Means shall be provided to ensure that, when a notched 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.

The vice shall be positioned so that the test specimen is central, to within $\pm$ 0,05 mm, to the striking edge and so that the centre of the striking edge is 22,0 mm $\pm$ 0,2 mm above the top plane of the vice (see figure 2). The vice shall be designed to prevent the clamped portion of the test specimen from moving during the clamping or testing operations.

NOTE 4 The fixed vice jaw may be provided with a groove to improve positioning and handling of the test specimen (see figure 1).

5.1.7 Some plastics are sensitive to clamping pressure. When testing such materials, a means of standardizing the clamping force shall be used and the clamping force shall be recorded in the test report. The clamping force can be controlled by using a calibrated torque wrench or a pneumatic or hydraulic device on the vice clamping screw.

5.2 Micrometers and gauges

Micrometers and gauges suitable for measuring the essential dimensions of the test specimens to an accuracy of 0,02 mm are required. For measuring the dimension b_N of notched specimens, the micrometer shall be fitted with an anvil of width 2 mm to 3 mm and of suitable profile to fit the shape of the notch.

6 Test specimens

6.1 Preparation

6.1.1 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 moulded 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 sheets that have been compression or injection moulded from the compound.

NOTE 5 Type 1 specimens may be taken from the central part of the test specimen type A complying with ISO 3167 (see 6.3).

6.1.2 Sheets

Specimens shall be machined from sheets in accordance with ISO 2818. Whenever possible, specimens of type 1 with notch A shall be used. The machined surface of unnotched specimens shall not be tested under tension.

6.1.3 Long-fibre-reinforced polymers

A panel shall be prepared in accordance with ISO 1268 or another specified or agreed upon preparation procedure. Specimens shall be machined in accordance with ISO 2818.

6.1.4 Checking

The specimens shall be free of twist and shall have mutually perpendicular parallel surfaces. The surfaces and edges shall be free from scratches, pits, sink marks and flash.

The specimens shall be checked for conformity with these requirements by visual observation against straightedges, squares and flat plates, and by measuring with micrometer calipers.

Specimens showing measurable or observable departure from one or more of these requirements shall be

rejected or machined to proper size and shape before testing.

6.1.5 Notching

6.1.5.1 Machined notches shall be prepared in accordance with ISO 2818. The profile of the cutting tooth shall be such as to produce in the specimen a notch of the contour and depth shown in figure 3, at right angles to its principal axes.

6.1.5.2 Specimens with moulded-in notches may be used if specified for the material being tested. Specimens with moulded-in notches do not give results comparable to those obtained from specimens with machined notches.

6.2 Anisotropy

Certain types of sheet or panel materials may show different impact properties according to the direction in the plane of the sheet or panel. In such cases, it is customary to cut groups of test specimens with their major axes respectively parallel and perpendicular to the direction of some feature of the sheet or panel which is either visible or inferred from knowledge of the method of its manufacture.

6.3 Shape and dimensions

The preferred specimen is of type 1 with the following dimensions, in millimetres:

length:	$l = 80 \pm 2$
width:	$b = 10{,}0 \pm 0{,}2$
thickness:	$h = 4{,}0 \pm 0{,}2$

With respect to existing apparatus, the length may be shortened symmetrically to 63,5 mm.

Additional types 2, 3 and 4 are described in annex A.

The longitudinal direction of the notch is always parallel to the thickness h.

6.3.1 Moulding or extrusion compounds

Type 1 test specimens with two different types of notch shall be used as specified in table 2 and shown in figure 3. The notch shall be located at the centre of the specimen.

The preferred type of notch is type A. If information on the notch sensitivity of the material is desired, specimens with notch types A and B shall be tested.

6.3.2 Sheet materials, including long-fibre-reinforced polymers

The recommended thickness h is 4 mm. If the specimen is cut from a sheet or a piece taken from a structure, the thickness of the specimen, up to 10,2 mm, shall be the same as the thickness of the sheet or the structure.

Specimens taken from pieces thicker than 10,2 mm shall be machined to 10 mm ± 0,2 mm from one surface, providing that the sheet is homogeneous in its thickness and contains only one type of reinforcement regularly distributed. If unnotched specimens are tested according to 3.1, the original surface shall be tested under tension, in order to avoid surface effects.

Specimens are tested edgewise in the parallel direction with the exception of specimens with $h = b = 10$ mm, which can be tested parallel and normal to the sheet plane (see figure 1).

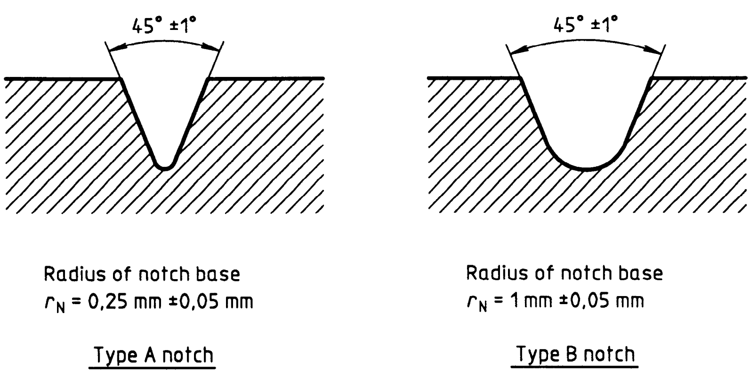


Figure 3 — Notch types

Table 2 — Method designations, specimen types, notch types and notch dimensions

Dimensions in millimetres

Method designation[1]	Specimen type	Notch type[1]	Notch base radius r_N	Remaining width, b_N, at notch base
ISO 180/1U [2]	1 [3]	unnotched	—	—
ISO 180/1A		A	0,25 ± 0,05	8,0 ± 0,2
ISO 180/1B		B	1,00 ± 0,05	8,0 ± 0,2

1) Attention is drawn to changes in method designations and notch type designations from those used in ISO 180:1982.

2) If specimens are taken from sheets or products, the thickness of the sheet or product shall be added to the designation and unreinforced specimens shall not be tested with their machined surface under tension.

3) If the sheet thickness h equals the width b, the blow direction (normal n, or parallel p) should be added to the designation.

6.4 Number of test specimens

6.4.1 Unless otherwise specified in the standard for the material being tested, a set consisting of a minimum 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.

6.4.2 If laminates are tested in the parallel and normal directions, ten specimens shall be used for each direction.

6.5 Conditioning

Unless otherwise specified in the standard for the material under test, the specimens shall be conditioned for at least 16 h at 23 °C and 50 % relative humidity according to ISO 291, unless other conditions are agreed upon by the interested parties.

7 Procedure

7.1 Conduct the test in the same atmosphere as that used for conditioning, unless otherwise agreed upon by the interested parties, e.g. for testing at high or low temperatures.

7.2 Measure the thickness, h, and the width, b, of each test specimen, in the centre, to the nearest 0,02 mm. In the case of notched specimens, carefully measure the remaining width b_N to the nearest 0,02 mm.

NOTE 6 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 in 6.3.

With multiple-cavity moulds, ensure that the dimensions of the specimens are the same for each cavity.

7.3 Check that the pendulum machine has the specified velocity of impact (see table 1) and that it is in the correct range of absorbed energy W, which shall be between 10 % and 80 % of the pendulum energy E. If more than one of the pendulums described in table 1 meet these requirements, the pendulum having the highest energy shall be used.

7.4 Carry out a blank test (i.e. without a specimen in place) and record the measured values of the total frictional loss. Ensure that this energy loss does not exceed the appropriate value given in table 1.

If frictional losses are equal to or less than the values indicated in table 1, they may be used in the calculations of corrected energy absorbed. If frictional losses exceed the values indicated in table 1, care should be taken to evaluate the cause of any excess frictional losses and corrections made as necessary to the equipment.

7.5 Lift and support the pendulum. Place the specimen in the vice and clamp it in accordance with 5.1.6 and as shown in figure 2. 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 2).

7.6 Release the pendulum. Record the impact energy absorbed by the specimen and apply any necessary corrections for frictional losses etc. (see table 1 and 7.4).

7.7 Four types of failure according to the following letter codes may occur:

C complete break; a break in which the specimen separates into two or more pieces

H hinge break; an incomplete break such that both parts of the specimen are held together only by