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

Plastiques — Vérification des machines d'essai de choc pendulaire — Essais de choc Charpy, Izod et de choc-traction

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

This second edition cancels and replaces the first edition (ISO 13802:1999), which has been technically revised. It also incorporates the Technical Corrigendum ISO 13802:1999/Cor.1:2000.

This corrected version of ISO 13802:2015 incorporates the following correction:

— in Table 4, the pendulum length, L_P, in m, has been changed from "0,225 to 0,390" to "0,221 to 0,417".

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

1 Scope

This International Standard specifies frequency and methods for the verification of pendulum impact-testing machines used for the Charpy impact test, Izod impact test, and tensile impact test described in ISO 179-1, ISO 180, and ISO 8256, respectively. Verification of instrumented impact machines is covered insofar as the geometrical and physical properties of instrumented machines are identical to non instrumented machines. The force/work verification of instrumented machines is not covered in this International Standard.

This International Standard is applicable to pendulum-type impact-testing machines, of different capacities and/or designs, with the geometrical and physical properties defined in Clause 5.

Methods are described for verification of the geometrical and physical properties of the different parts of the test machine. The verification of some geometrical properties is difficult to perform on the assembled instrument. It is, therefore, assumed that the manufacturer is responsible for the verification of such properties and for providing reference planes on the instrument that enable proper verification in accordance with this International Standard.

These methods are for use when the machine is being installed, has been repaired, has been moved, or is undergoing periodic checking.

A pendulum impact-testing machine verified in accordance with this International Standard, and assessed as satisfactory, is considered suitable for impact testing with unnotched and notched test specimens of different types.

Annex A details design requirements for Charpy testing machines.

Annex B details design requirements for Izod testing machines.

Annex C details design requirements for tensile impact machines.

Annex D explains how to calculate the ratio of frame mass to pendulum mass required to avoid errors in the impact energy.

Annex E explains deceleration of pendulum during impact.

Annex F details design requirements for one type of gauge used to verify striker and anvil/support alignment for Charpy testing machine.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 8256, *Plastics — Determination of tensile-impact strength*

3 Terms and definitions

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

3.1
verification
proof, with the use of calibrated standards or standard reference materials, that the calibration of an instrument is acceptable

3.2
calibration
set of operations that establish, under specified conditions, the relationship between values indicated by a measuring instrument or measuring system and values corresponding to appropriate standards or known values derived from standards

3.3
period of oscillation of the pendulum
T_P
period, expressed in seconds, *s*, of a single complete oscillation of the pendulum, oscillating at angles of oscillation of less than 5°, on average, to each side of the vertical

3.4
centre of percussion
point on a pendulum at which a perpendicular impact in the plane of swing does not cause reaction forces at the axis of rotation of the pendulum

3.5
pendulum length
L_P
distance, expressed in metres, between the axis of rotation of the pendulum and the *centre of percussion* (3.4) and it is the distance from the axis of rotation where the mass of a pendulum would have to be concentrated to have the same period of swing, T_P, as the actual pendulum

3.6
gravity length
Lm
distance, expressed in metres, between the axis of rotation of the pendulum and the centre of gravity of the pendulum

3.7
gyration length
L_G
distance, expressed in metres, between the axis of rotation of the pendulum and the point at which the pendulum mass, m_P, would have to be concentrated to give the same moment of inertia as the pendulum

3.8
impact length
L_I
distance, expressed in metres, between the axis of the rotation of the pendulum and the point of impact of the striking edge at the centre of the specimen face

3.9
release angle
α_0
angle, expressed in degrees, relative to the vertical, from which the pendulum is released

Note 1 to entry: Usually, the test specimen is impacted at the lowest point of the pendulum swing (α_0 = 0°). In this case, the release angle will also be the angle of fall [see Figure 1b)].

3.10
impact velocity
v_I
velocity, expressed in metres per second, of the pendulum at the moment of impact

3.11
potential energy
E
potential energy, expressed in joules, of the pendulum in its starting position, relative to its position at impact

3.12
impact energy
W
energy, expressed in joules, required to deform, break, and push away the test specimen

3.13
frame
part of the machine carrying the pendulum bearings, the supports, the vice and/or clamps, the measurement instruments, and the mechanism for holding and releasing the pendulum

Note 1 to entry: The mass of the frame, m_F, is expressed in kilograms.

3.14
base
part of the framework of the machine located below the horizontal plane of the supports

3.15
anvil
portion of the machine that serves to properly position the test piece for impact, with respect to the striker and the test piece supports, and supports the test piece under the force of the strike

3.16
test specimen supports
portion of the machine that serves to properly position the test specimen for impact, with respect to the centre of percussion of the pendulum, the striker, and the anvils

3.17
striker
portion of the pendulum that contacts the test piece

3.18
period of oscillation of the frame
T_F
period, expressed in seconds, of the freely decaying, horizontal oscillation of the frame and it characterizes the oscillation of the frame vibrating against the stiffness of the (resilient) mounting, e.g. a test bench and/or its foundation (which may include damping material for instance) (see Annex D)

3.19
mass of the pendulum
$m_{P,max}$
mass, expressed in kilograms, of the heaviest pendulum used

3.20
Izod/Charpy impact reference specimen
specimen made from stainless steel 80 mm ± 0,05 mm in length and of rectangular section, 10 mm ± 0,02 mm in height, and 10 mm ± 0,02 mm in width

3.21
half-height Charpy impact reference specimen
specimen made from stainless steel 80 mm ± 0,05 mm in length and of rectangular section, 5 mm ± 0,02 mm in height, and 10 mm ± 0,02 mm in width

3.22
tensile impact reference specimen
specimen made from stainless steel 80 mm ± 0,05 mm in length and of rectangular section, 10 mm ± 0,02 mm in height, and 4 mm ± 0,02 mm in width

4 Measurement instruments

The verification methods described in this International Standard call for the use of straight edges, vernier calipers, set squares, levels and dynamometers, load cells or scales, and timing devices to check if the geometrical and physical properties of the components of the test machine conform to the requirements given in this International Standard.

These measurement instruments shall be accurate enough to measure the parameters within the tolerance limits given in Clause 6 (Table 4).

5 Description of a pendulum impact-testing machine

5.1 Types of pendulum impact-testing machines

Three different types of test machines are covered by this International Standard. Annex A contains details of construction and performance of a machine configured for Charpy testing. Figure A.1 shows a typical example of a Charpy test machine. Important values to be verified are listed in Table A.1. Test conditions are found in ISO 179.

Annex B contains details of construction and performance of a machine configured for Izod testing. Figure B.1 shows a typical example of an Izod test machine. Important values to be verified are listed in Table B.1. Test conditions are found in ISO 180.

Annex C contains details of construction and performance of a machine configured for tensile impact testing. Figures C.1 and C.2 show typical examples of tensile impact-testing machines. Important values to be verified are listed in Table C.1. Test conditions are found in ISO 8256.

5.2 Testing machine components

A pendulum impact testing machine consists of the following parts:

5.2.1 Machine frame — The base of the machine and the structure supporting the pendulum

5.2.1.1 Bearings.

5.2.1.2 Mechanism for holding and releasing the pendulum.

5.2.1.3 Base.

5.2.2 Pendulum

5.2.2.1 Pendulum rod or compound (bifurcated) design.

5.2.2.2 Striker, with striking edge for Charpy or Izod impact tests or with striking surfaces or clamps for tensile impact testing (see ISO 8256, test methods A and B respectively).

5.2.2.3 Add-on weights (optional), for increasing potential energy capacity of pendulum.

NOTE There are several pendulum designs available, and they are acceptable if they meet the requirements of this International Standard.

5.2.3 Test specimen anvils, supports, clamps and/or holders

5.2.3.1 Anvils and test specimen supports, for Charpy impact testing.

The Charpy test supports and anvils shall be located one on each side of the plane of swing of the pendulum. The anvils shall be installed perpendicular to the supports and normal to the plane of swing of the pendulum. Essentially, the specimen rests on the supports and the anvil takes the reaction from the impact on the specimen.

NOTE Recesses in the supports to accommodate flash on specimens are permitted.

5.2.3.2 Vice, for Izod impact testing.

5.2.3.3 Clamps or stops, for tensile impact testing (see ISO 8256, methods A and B).

5.2.3.4 Crossheads, for tensile impact testing (see ISO 8256, methods A and B).

5.2.4 Indicating equipment for absorbed energy (e.g. scale and friction pointer or electronic readout device)

6 Procedure for verification and inspection of a pendulum impact-testing machine

6.1 Certification of machine design and manufacturer

There are several aspects of the design and manufacture of an impact machine that are critical to its performance and can only be certified at the time of manufacture by the manufacturer, including the following (see Table 1).

6.1.1 Centre of percussion.

6.1.2 Axis of rotation.

6.1.3 Pendulum plane of swing.

6.1.4 Mass of frame.

Unless the ratio, $m_F/m_{P,max}$, of the mass of the frame to the mass of the heaviest pendulum used is at least 40, the frame shall be bolted to a rigid test bench.

Since many machines may not have been supplied with manufacturer's certificates detailing the ratio of the mass of the frame to the mass of the pendulum, bolting the machine to the test bench and levelling with shims is strongly recommended.

Table 1 — Components of impact machine to be certified only at the time of manufacture

Parameter	Unit	Value
Centre of percussion	mm	At the centre of strike ±2,5
Axis of rotation of pendulum[a]	—	Parallel within ±2/1 000 relative to the reference plane
Plane of swing relative to axis of rotation	—	90° ± 0,1° to the axis of rotation
Mass of frame	kg	At least 40 times the weight of the heaviest pendulum used or bolted to a heavy secure bench

[a] The reference plane of a particular machine will vary by manufacturer.

6.2 Field verification of the machine frame shall consist of determining the following items (see Table 4)

6.2.1 Installation

The pendulum impact-testing machine shall be installed on a sturdy bench or table in an area that is free from vibration. If the machine is equipped with levelling adjustment screws, the adjustment screws shall be fixed after levelling in order to maintain the frame in position and the stiffness of the mounting. During an impact test, there shall be no visible displacement of the frame on its support. Verify that there is no movement of either the machine or the test bench by configuring the machine with the highest energy capacity pendulum available on the machine. Latch the pendulum and place a level on the base. Release the pendulum and observe the level for any movement of the bubble. Any bubble movement observed requires that the machine be mounted in a more secure manner.

6.2.2 Levelness

Determine the levelness of the reference plane in the direction of the swing and perpendicular to the swing. The machine shall be installed so that the reference plane is horizontal to within 2/1 000.

6.2.3 Axial play of the pendulum bearings

The endplay in the bearings of the pendulum spindle in the axial direction shall not exceed 0,25 mm.

6.2.4 Radial play of the pendulum bearings

Determine the radial play of the shaft in the pendulum bearings when a torque of 2 ± 0,2 N is applied in alternate directions perpendicular to the plane of swing of the pendulum. The total play in the radial direction should not exceed 0,05 mm.

6.2.5 Mechanism for holding and releasing the pendulum

The mechanism for releasing the pendulum from its initial position shall be visually inspected. A properly functioning release mechanism operates freely and permits the release of the pendulum without initial impulse, retardation or side vibration, or any other interference that would result in energy loss.

6.2.6 Free hanging position

When hanging free, the pendulum shall hang so that the striking edge is within 6,35 mm of the position where it would just touch the reference specimen.

6.2.7 Contact between specimen and striking edge (Izod/Charpy)

For Izod and Charpy machines, the striker shall make contact over the full width of the Izod/Charpy impact reference specimen defined in 3.20.

One method of verifying this is as follows. A Izod/Charpy impact reference specimen is tightly wrapped in thin paper (e.g. by means of adhesive tape), and is placed in the specimen supports or clamp. Similarly, the striker edge is tightly wrapped in carbon paper with the carbon side outermost (i.e. not facing the striker). From its position of equilibrium, the pendulum is raised a few degrees, released so that it contacts the Izod/Charpy impact reference specimen, and prevented from contacting the test piece a second time. The mark made by the carbon paper on the paper covering the Izod/Charpy impact reference specimen should extend completely across the paper. This test may be performed concurrently with that of checking the angle of contact between the striker and the Izod/Charpy impact reference specimen.

6.2.8 Potential energy, *E*

Table 2 shows the nominal potential energy values of pendulums typically used in Charpy, Izod, and tensile impact machines. The potential energy, E, shall not differ by more than 1 % of the nominal value given in Table 2. It shall be determined as follows:

a) Support the pendulum at an arbitrary length, L_H, from the axis of rotation, on a balance or dynamometer. Ensure that the line from the axis of rotation to the centre of gravity of the pendulum is horizontal [see Figure 1a)].

b) Measure the vertical force, F_H, in newtons, at L_H and the length, L_H, in metres, to a precision of ±1,0 %.

c) Calculate the horizontal moment, M_H, of the pendulum about the axis of rotation, in newton metres, using the formula:

$$M_H = F_H L_H \qquad (1)$$

d) Measure the release angle, α_0 [see Figure 1b)], to a precision $\Delta\alpha_0$, which corresponds to a relative precision of 1/400th of the potential energy, E, and, if applicable, the impact angle, α_I, to within 0,25°. Thus, for starting angles of 140°, 150°, and 160°, $\Delta\alpha_0$ is 0,39°, 0,54°, and 0,81°, respectively.

e) Calculate the potential energy, E, of the pendulum from the following formula:

$$E = M_H(\cos\alpha_I - \cos\alpha_0) \qquad (2)$$

where

E is the potential energy of the pendulum, in joules;

M_H is the horizontal moment of the pendulum [see Formula (2)], in newton metres;

α_0 is the release angle, in degrees;

α_I is the impact angle, in degrees.

NOTE 1 Most pendulum impact-testing machines use an impact angle of 0°, for which $\cos\alpha_I = 1$.

NOTE 2 In certain cases, it may be necessary to remove the pendulum from the machine to determine its moment, M_H, by the method described.

Table 2 — Basic characteristics of Charpy, tensile, and Izod impact-testing machines

Nominal potential energy E J	Type of test	Impact velocity v_I m/s	Maximum permissible losses due to friction without test specimen % of E
0,5	Charpy	2,9 (±10 %)	4
1,0	Charpy		2
2,0	Charpy/Tensile		1
4,0	Charpy/Tensile		0,5
5,0	Charpy		0,5
7,5	Charpy/Tensile	3,8 (±10 %)	0,5
15	Charpy/Tensile		
25	Charpy/Tensile		
50	Charpy/Tensile		
1,0	Izod	3,5 (±10 %)	2
2,75	Izod		1
5,5	Izod		0,5
11	Izod		0,5
22	Izod		0,5

6.2.9 Pendulum length, L_P

The pendulum length, L_P, shall be certified by the manufacturer at the time of manufacture. Under normal conditions, it should not change but it shall be verified, if repaired or replaced, as part of the calibration procedure. The pendulum length shall be determined for each available pendulum.

Determine the pendulum length to within the precision specified (see Table 3).

The pendulum length is verified by measuring the period of oscillation (time of swing), T_P, of the pendulum. Raise the pendulum and release from a height that results in a swing of a maximum of 5°, on average, and measuring the time of a complete swing in seconds. Determine the period of oscillation as the mean value of four determinations.

Table 3 — Examples of minimum number of oscillations for determination of T_P

L_P m	T_P s	Accuracy of time measurement s	Minimum number of oscillations n
0,225	0,95	0,1	50
		0,01	10
0,390	1,25	0,1	50
		0,01	10

NOTE Hand-held stopwatches are generally considered to have an accuracy of 0,1 s. Integrated electronic timing devices are required to give greater accuracy of time measurement.

Determine the pendulum length, L_P, from the period of oscillation, T_P, of the pendulum using Formula (3):

$$L_P = \frac{gT_P^2}{4\pi^2} \quad (3)$$

where

T_P is the period of oscillation of the pendulum, in seconds;

g is taken as equal to 9,81 m/s^2, however, if the local acceleration of gravity is known or is believed to be significantly different from 9,81 m/s^2, the local acceleration of gravity shall be used;

π^2 is taken as equal to 9,87.

Therefore, in meters, L_P = 0,2485 T_P^2.

The value of T_P shall be determined to a precision of 0,5 %.

6.2.10 Impact length, L_I

The impact length, L_I (3.8), shall be within 1 % of the pendulum length, L_P, as determined from the period of oscillation, T_P, of the pendulum [see Formula (3) and Figure 1a)].

6.2.11 Velocity of the pendulum at instant of impact, v_I,

The impact velocity, v_I, shall have the value given in Table 4 for Charpy, Izod, and tensile impact testing, respectively.

Determine the impact velocity using Formula (4):

$$v_I = \sqrt{2gL_I(\cos\alpha_I - \cos\alpha_0)} \quad (4)$$

where

v_I is the impact velocity, in metres per second;

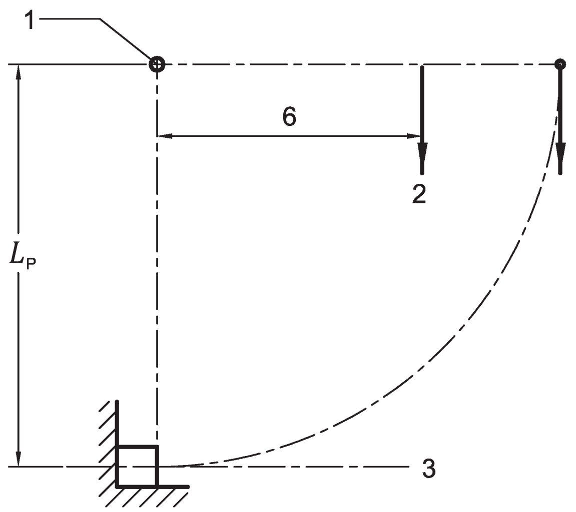
g may be taken as 9,81 m/s^2 (to save measurement at the site of each testing machine);

L_I is the impact length, in metres;

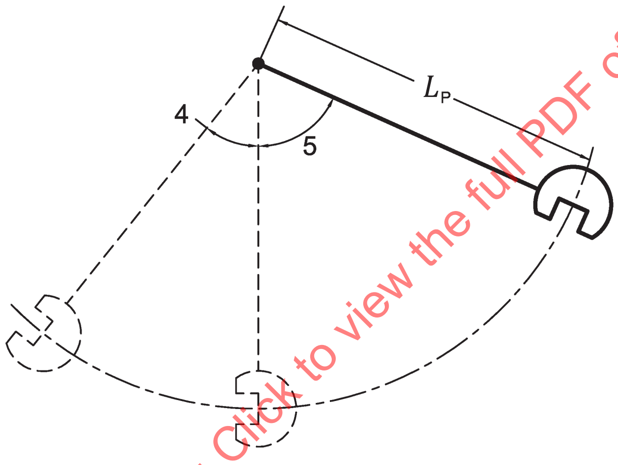
α_0 is the release angle, in degrees;

α_I is the impact angle, in degrees.

NOTE In most cases, the impact angle is 0°, i.e. cos α_I = 1.



a) Quantities for determining the horizontal moment



b) Quantities for scale calibration and potential energy calculations

Key

1 axis of rotation

2 vertical force, F_H

3 centre of percussion

4 angle of rise, α_R

5 release angle, α_0

6 arbitrary length from the axis of rotation, that the pendulum is supported on a balance or dynamometer, L_H

Figure 1 — Quantities necessary for energy verification

6.3 Charpy testing machines

Inspection and verification of Charpy machines (see Figure A.1 and Table A.1) shall consist of the following:

6.3.1 Position of anvils, relative to striking edge.

The clearance between the anvils and the striker, or any adjacent part of the pendulum that pass between the anvils, should be sufficient to ensure that the broken specimen is free to leave the machine with the minimum of interference, thus, preventing the possibility of the specimen rebounding into the pendulum. Any end stop used for locating the test specimen in the anvils should not impede the movement of the specimen during the test.

6.3.2 Contact between Charpy striker and specimen.

6.3.3 Angle between the line of contact of the striker and the horizontal axis of the Izod/Charpy impact reference specimen (see Figure A.1).

6.3.4 Angle of striker, θ_1.

6.3.5 Radius of striking edge, R_1.

6.3.6 Parallelism (Orientation) of supports, p_1.

6.3.7 Radius of anvils, R_2.

6.3.8 Angle of taper of anvils, θ_2.

6.3.9 Angle of slope of anvils, θ_3.

6.3.10 Angle between supports and anvils surfaces, θ_4.

6.3.11 Span between the supports.

NOTE The span between the supports varies with specimen type.

6.3.12 Location of notch.

If means is provided for locating the test specimen, it shall ensure that the plane of symmetry of the notch lies within ±0,5 mm of the centre of the gap between the specimen anvils.

NOTE One type of a gauge that can be used to check the distance between the anvils and their alignment relative to the striking edge is shown in Annex F.

6.4 Izod testing machines

Inspection and verification of Izod machines (see Figure B.1 and Table B.1) shall consist of the following:

6.4.1 Line of contact of the striker

6.4.2 Striking edge of pendulum for Izod test machines. The striker or tup shall conform to all of the requirements listed below.

6.4.2.1 Radius, R_1. The striking edge of the striker or tup shall have a cylindrical surface with its axis horizontal and perpendicular to the plane of motion of the pendulum.

6.4.2.2 Angle relative to the longitudinal axis of the Izod/Charpy impact reference specimen, θ_1. When it contacts the Izod/Charpy impact reference specimen, the striking edge, which shall be centred and extended beyond both sides of the Izod/Charpy reference specimen.

6.4.2.3 Parallelism, p_1, with face of Izod/Charpy impact reference specimen (over full width).

6.4.3 Specimen vice. Vice (clamping and support blocks) designed to hold the test specimen in Izod machines (see Figure B.1) shall conform to all of the requirements listed below.

6.4.3.1 Parallelism of vice faces in horizontal and vertical direction. With an Izod/Charpy impact reference specimen clamped in place, the vice faces shall be parallel in both the horizontal and the vertical direction, p_3.

6.4.3.2 Horizontality of the top surface of the vice, relative to reference plane, p_2.

6.4.3.3 Angle between the faces of the support block/clamping block and top surface of vice, θ_2.

NOTE In addition, use a straight edge and a hand-held light to check for wear. Any indication of light between the straight edge and the support block indicates that the support block is worn and that it needs to be replaced.

6.4.3.4 Radius of support block. Verify the top edge of the support, about which bending takes place, R_2.

6.4.3.5 Location of striking edge above top surface of support, D_1.

6.4.4 Location of specimen and striker

When a reference specimen is located in the vice and clamped so that it is attached rigidly to the frame, the following requirements shall be conformed to:

a) top surface of the support block shall be parallel, to within 3/1 000, to the reference plane of the machine;

b) longitudinal axis of the specimen shall be perpendicular, to within ±0,5°, to the top surface of the support block;

c) notch, which shall face the striker, shall be perpendicular to the plane of swing of the pendulum, and the plane of symmetry of the notch shall coincide with the top surface of the support block, both within ±0,1 mm;

d) when it contacts the specimen, the striking edge, which shall be sufficiently wide to extend beyond both sides of the specimen, shall be perpendicular, to within ±2°, to the longitudinal axis of the specimen and parallel, to within 0,025 mm (= 0,36°), to the face of the specimen, over the full width of the specimen.

6.4.5 Vice faces

With a specimen clamped in place, the vice faces shall be parallel, to within 4/1 000, in both the horizontal and the vertical direction.

6.5 Tensile impact testing machines (see ISO 8256)

Inspection and verification of tensile impact machines (see Figures C.1 and C.2 and Table C.1) shall consist of the following:

6.5.1 Specimen clamps for tensile impact test machines

6.5.1.1 Method A

The specimen clamps surfaces shall be coplanar.

The specimen clamps shall be parallel to the axis of rotation of the pendulum.

When using a tensile impact reference specimen, the centres of the contact areas on the crossheads and on the striker shall lie in a plane which is horizontal to within 2° and within ±0,5 mm of the plane of swing of the pendulum.

6.5.1.2 Method B

When clamped in place, tensile impact reference specimen shall lie in the plane of swing of the pendulum to within ±0,5 mm and in such a way that its longitudinal axis is parallel, to within 4/1 000, to the plane of swing of the pendulum.

The contact surfaces on the crosshead, mounted on a rectangular reference specimen, shall be coplanar and parallel, to within 5/1 000, to the axis of rotation of the pendulum.

6.5.2 Clamps for tensile impact testing

For specimen types 1, 2, 3, and 4 (see ISO 8256, Table 2 and Figure 3), the surfaces between which the specimen is clamped shall be such that there is no slippage when the blow is struck. This applies to the jaw faces of the clamps attached to the frame or striker, as well as to the crossheads. The clamps shall be of such a design that they do not contribute to the failure of the specimen.

Jaws of the clamp may have file-like serrations, and the size of the serrations shall be selected, according to experience, to suit the hardness and toughness of the specimen material and its thickness. 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.

For type 5 specimens (see ISO 8256, Table 2 and Figure 3), held only by embedding, a pair of notched jaws of different heights is necessary. The pair of jaws chosen for the test shall have a height which is greater than the thickness of the specimen but less than 120 % of its thickness.

6.5.3 Alignment

When clamped in place, the specimen shall lie the plane of swing of the pendulum to within ±0,5 mm.

6.5.4 Mass of crosshead

Depending on the energy of the pendulum used, crossheads of different masses have to be used. Ensure, by weighing, that the crosshead mass conforms to the limits given in ISO 8256, Table 1.

6.6 Energy indicating system

6.6.1 Types of scale

The machine may be graduated either in angle of rise, α_R [see Figure 1b)] or in impact energy, W, absorbed, the two being related by Formula (5):

$$W = M_H(\cos\alpha_R - \cos\alpha_0) \tag{5}$$

where

- W is the impact energy, in joules;
- M_H is the horizontal moment of the pendulum, as given by Formula (1), in newton metres;
- α_0 is the starting angle, expressed in degrees;
- α_R is the angle of rise, in degrees.

NOTE It may be useful to have the scale graduated both in joules of absorbed energy and in degrees. Also, for the installation and calibration of the machine and the measurement of friction losses, it is useful to be able to change the starting angle.

6.6.2 Verification of analogue indicating equipment shall consist of the following examinations

a) examination of the scale graduations;

b) examination of the indication pointer.

The scale shall be graduated in units of angle of rise, $\alpha_{R,1}$, or of energy absorbed, W_I.

The thickness of the graduation marks on the scale shall be uniform and the width of the pointer shall be approximately equal to the width of a graduation mark. The indicating pointer shall permit a reading free from parallax.

The resolution, *r*, of the indicator is obtained from the ratio between the width of the pointer and the centre-to-centre distance between two adjacent scale-graduation marks (scale interval), the recommended ratios are 1:4, 1:5, or 1:10; a spacing of 2,5 mm or greater is required to estimate a tenth of a division on the scale.

The scale interval shall be at most 1 % of the nominal absorbed energy and shall permit the estimation of energy in increments of better than 0,25 % of the nominal absorbed energy.

6.6.3 Error in the indicated absorbed energy, W_i, on analogue indicating systems

a) The graduation marks on the scale corresponding approximately to values of absorbed energy of 10 %, 20 %, 30 %, 50 %, and 80 % of the range of the nominal potential energy shall be verified.

b) Operate the machine normally, but without a test specimen in position, and obtain a zero reading ($W_{S,1}$) as indicated by the pointer. Record this reading, which shall not exceed ±2,5 % of the potential energy, *E*.

c) Support the pendulum so that the zero reading ($W_{S,1}$) is indicated by the pointer and measure the corresponding angle of rise, $\alpha_{R,1}$.

d) Support the pendulum so that the mark for each of the above calibration positions is indicated by the pointer, and measure the corresponding angle of rise, $\alpha_{R,i}$, for each position.

e) Calculate the absorbed energy, W_i, using Formula (6):

$$W_i = M_H(\cos \alpha_{R,i} - \cos \alpha_{R,1}) \tag{6}$$

NOTE The precision specified for L_l and F_H and for $\alpha_{R,1}$ and $\alpha_{R,i}$ enables W_i to be determined to a precision of approximately 0,3 % of full-scale deflection.

f) Repeat steps a) to d) twice.

g) Calculate the mean of the three determinations. The difference between the individual values and their mean shall not exceed 1 % of the energy corresponding to the indicated value or 1 % of the full-scale value, whichever is the greater.

6.6.4 Verification of digital indicating equipment shall ensure that the following requirements are met

The scale shall be graduated in units of angle or of energy.

The resolution of the scale is considered to be one increment of the last active number of the digital indicator provided that the indication does not fluctuate by more than one increment. When the readings fluctuate by more than one increment, the resolution is taken to be equal to half the range of fluctuation.

The resolution shall be better than 0,25 % of the nominal absorbed energy.

For machines equipped with digital displays, the settings in the display should be verified so that they correspond to the potential energy of the pendulum installed on the testing machine.

6.7 Losses due to friction

6.7.1 Types of loss

Energy is absorbed by friction, including in the pointer (if present) or in electronic angular-displacement transducers, air resistance, and friction in the pendulum bearings.

6.7.2 Determination of the loss due to friction in the pointer

If the machine has a pointer, determine the loss due to friction in the pointer, $W_{f,P}$, using the following procedure:

a) Operate the machine normally, but without a test specimen, to obtain a first reading, $W_{f,1}$.

b) Without resetting the pointer, again release the pendulum from the initial position and obtain a second reading, $W_{f,2}$.

c) Repeat steps a) and b) twice.

d) Calculate the means of the three determination of $W_{f,1}$ and $W_{f,2}$.

e) Calculate the loss due to friction in the pointer, $W_{f,P}$, for one swing by subtracting the mean of the second readings, $W_{f,2}$, from the mean of the first readings, $W_{f,1}$, i.e:

$$W_{f,P} = W_{f,1} - W_{f,2} \tag{7}$$

6.7.3 Determination of losses due to air resistance and friction in the pendulum bearings

Determine the losses due to air resistance and friction in the pendulum bearings using the following procedure:

a) If the machine has a pointer, operate the machine as described in 6.6.2 to obtain a reading, $W_{f,2}$. Allow the pendulum to continue to swing freely. At the beginning of the tenth forward swing after measuring $W_{f,2}$, reposition the pointer so that, on completion of this swing, it is driven only a few divisions along the scale. Record the reading as $W_{f,3}$.

b) Repeat step a) twice.

c) Calculate the means of the three determinations of $W_{f,2}$ and $W_{f,3}$.

d) Calculate the energy lost due to air resistance and pendulum bearing friction, $W_{f,AB}$, for one swing using Formula (8)

$$W_{f,AB} = \frac{W_{f,3} - W_{f,2}}{20} \tag{8}$$

NOTE Electronic angular-displacement transducers are frequently used to measure pendulum motion. These devices are either frictionless optoelectronic devices or their frictional losses are included in $W_{f,AB}$.

6.7.4 Calculation of the total energy lost due to friction

Calculate the total energy lost due to friction, W_f, using Formula (9):

$$W_f = \frac{1}{2}\left[W_{f,AB} + \frac{\alpha_R}{\alpha_0}\left(W_{f,AB} + 2W_{f,P} \right) \right] \qquad (9)$$

6.7.5 Maximum permissible losses due to friction

The total losses due to friction for one swing shall not exceed the applicable value(s) given in Table 2.

The total energy lost, W_f, calculated from Formula (9), shall be subtracted from the impact energy measured with a test specimen, but only in cases when W_f exceeds 0,5 % of the potential energy, E, i.e. only for pendulums with a potential energy less than 4 J (see Table 4).

Table 4 — General characteristics of installed testing machine to be verified at regular intervals

Parameter	Symbol	Unit	Value
Sturdiness of installation			No vibrations
Level, parallel to plane of swing			Horizontal to within 2/1 000
Level, perpendicular to swing			Horizontal to within 2/1 000
Axial play of bearings		mm	0,25
Radial play of bearings		mm	0,05
Pendulum release		—	No energy loss
Free hang position – no weights added		mm	±5,0
Free hang position – max weight added		mm	±5,0
Contact between striking edge and specimen (Izod/Charpy)		—	Full contact
Potential energy	E	J	±1 % of nominal value
Pendulum length	L_P	m	0,221 to 0,417
Impact length	L_I	m	±1 % of pendulum length
Velocity at impact	v_I	m/s	See Table 2
Release angle	α_0	degrees	
Impact angle	α_I	degrees	
Charpy specific properties			
Frame/pendulum position			
Position of anvils, relative to striking edge	D_1	mm	Coincident to ±0,5
Striking edge of pendulum			
Angle of striker tip	θ_1	degrees	30° ± 1°
Radius of striking edge	R_1	mm	2,0 ± 0,5
Test specimen supports			
Parallelism (Orientation) between long axis of test specimen and reference plane (if present)	p_1		Parallel to within 4/1 000
Radius of curvature of anvils	R_2	mm	1 ± 0,1
Angle of taper of anvils	θ_2	degrees	10° ± 1°
Angle of slope of anvils	θ_3	degrees	5° ± 1°
Angle between supports and anvils	θ_4	degrees	90° ± 0,1°
Charpy support span		mm	±0,5 of requirement
Contact between Charpy striker and specimen			Full Contact
Angle of contact			Perpendicular within ±2°

Table 4 *(continued)*

Parameter	Symbol	Unit	Value
Izod Specific properties			
Frame/pendulum position			
Location of striking edge above top surface of support		mm	22 ± 0,2
Line of contact			Full contact
Striking edge			
Radius	R_1	mm	0,8 ± 0,2
Width			Centered
Angle relative to long axis of reference specimen	θ_1	degrees	90° ± 2,0°
Parallelism with face of Izod/Charpy impact reference specimen (over full width)			±0,025
Contact with reference specimen			Verify full contact
Izod specimen vice			
Parallelism in horizontal and vertical direction	p_3	mm	±0,5
Horizontality of top surface of vice	p_2		±3/1 000
Angle between support block/clamping block and top surface of vice	θ_2	degrees	90 ± 0,5
Radius of top edge of support block about which bending takes place	R_2	mm	0,2 ± 0,1
Line of contact, support block			Verify full contact
Tensile specific properties			
Pendulum			
Parallelism of clamp faces with crosshead face	p_1		±4/1 000
Angle between clamp faces and plane of swing	p_2	degrees	90 ± 1
Symmetry of clamp faces with respect to plane of swing	S_1	mm	±0,5
Test specimen position			
Symmetry with respect to plane of swing	S_2	mm	±0,5
Angle relative to plane of swing	p_3	degrees	±0,2
Crossheads			
For mass of crosshead, see ISO 8256, Table 1.			

7 Frequency of verification

A machine shall be verified if it is moved to a new location, or is subject to major repairs or adjustments, or if there is any reason to doubt the accuracy of the results it gives. Verifications shall be performed at regular intervals, depending on their design and the nature and extent of their use.

NOTE 1 An regular interval of two years is recommended for a machine which is in good order and is used under favourable conditions of service.

NOTE 2 During the period between successive complete verifications, partial verifications are recommended at intervals of one year for a machine which is in good order and is used under favourable conditions of service. For a partial verification, it is recommended to check the condition of pendulum (for compliance with 6.3); bearing (for compliance with 6.2.3 and 6.2.4); losses due to friction (for compliance with 6.7); and striker (for compliance with 6.4.1, 6.4.2, 6.4.3, 6.5.1, and 6.5.2).

NOTE 3 See Table 4 for an indication of properties that are to be verified regularly or initially, either by the manufacturer or after repairs, movement, etc.

8 Verification report

On completion of a complete verification, a report shall be issued. The report shall include the following information:

a) name and address of the verifying authority;

b) name and address of the client;

c) description of the machine, including, where relevant:

   1) maker,

   2) type or model,

   3) serial number,

   4) type or types of test, or

   5) nominal potential energy of each pendulum;

d) location of the machine;

e) date of verification

f) reference to this International Standard, i.e. ISO 13802;

g) details of any repairs and adjustments made;

h) mean values of $W_{f,1}$, $W_{f,2}$, and $W_{f,3}$ (see 6.7);

i) statement of conformity or otherwise to the requirements of Clause 6;

j) date of the report.

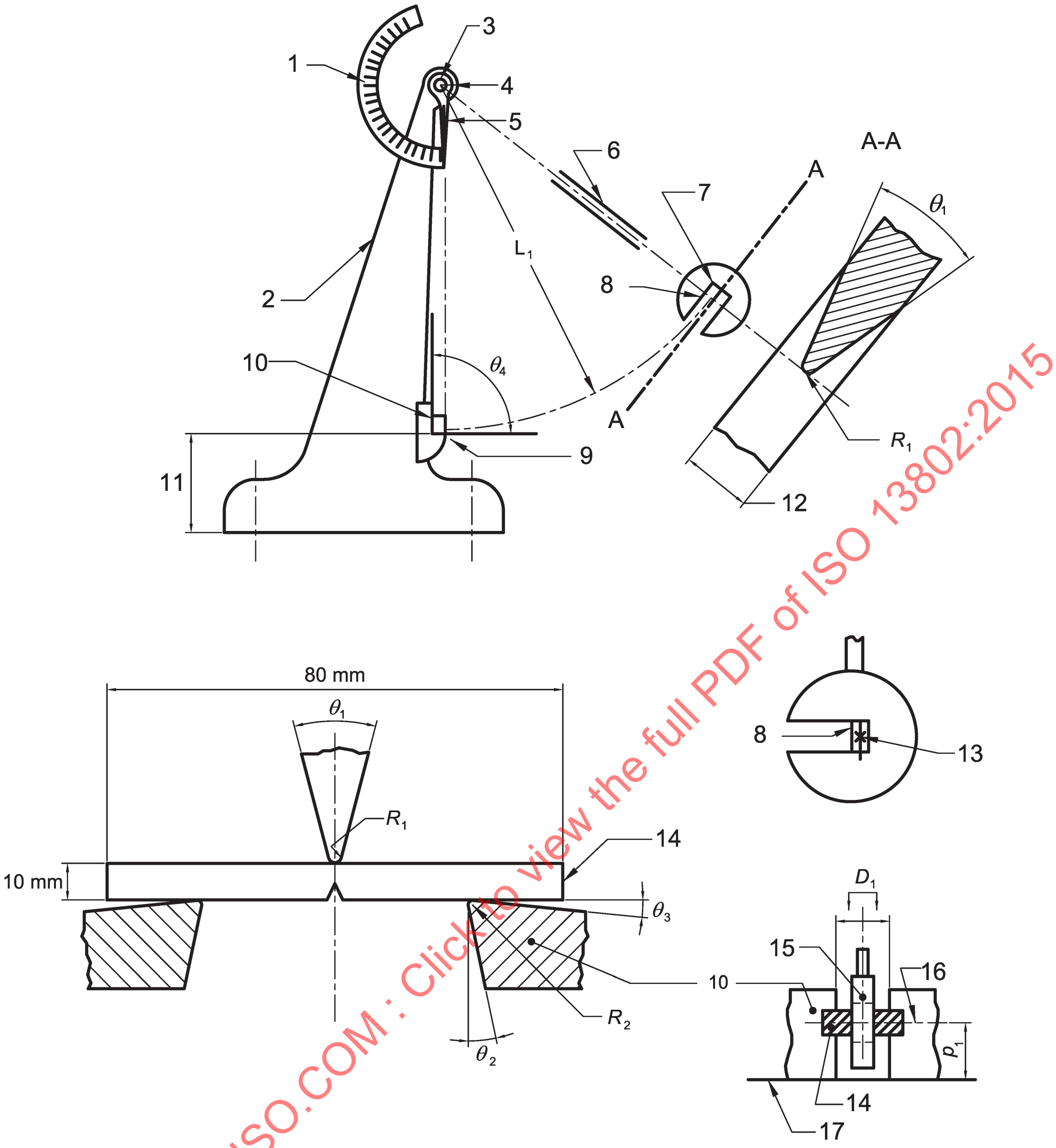
Annex A
(normative)

Design requirements for Charpy machines

The potential energy, E, shall not differ by more than ±10 % from the nominal value given in the first column of Table 2.

Table A.1 — Properties specific to Charpy machines

Parameter	Symbol used in Figure A.1	Unit	Value
Frame/pendulum position			
Position of supports, relative to striking edge	D_1	mm	±10
Striking edge of pendulum			
Angle of striker tip	θ_1	degrees	30° ± 1°
Radius of striking edge	R_1	mm	2,0 ± 0,5
Test specimen anvils and supports			
Parallelism (Orientation) between long axis of test specimen and reference plane (if present)	p_1	mm	Parallel to within 4/1 000
Radius of curvature of anvils	R_2	mm	1 ± 0,1
Angle of taper of anvils	θ_2	degrees	10° ± 1°
Angle of slope of anvils	θ_3	degrees	5° ± 1°
Angle between supports and anvils	θ_4	degrees	90° ± 0,1°
Charpy support span			±0,5 mm of requirement
Contact between Charpy striker and specimen			Full Contact
Angle of contact			Perpendicular within ±2°



Key

1 scale (analogue type)	10 anvils
2 machine frame	11 base
3 axis of rotation	12 width of striker
4 pendulum bearings	13 centre of percussion of striker
5 friction pointer	14 reference specimen
6 pendulum rod	15 line of contact
7 striker	16 axis of reference specimen
8 leading edge of striker	17 reference plane
9 supports	

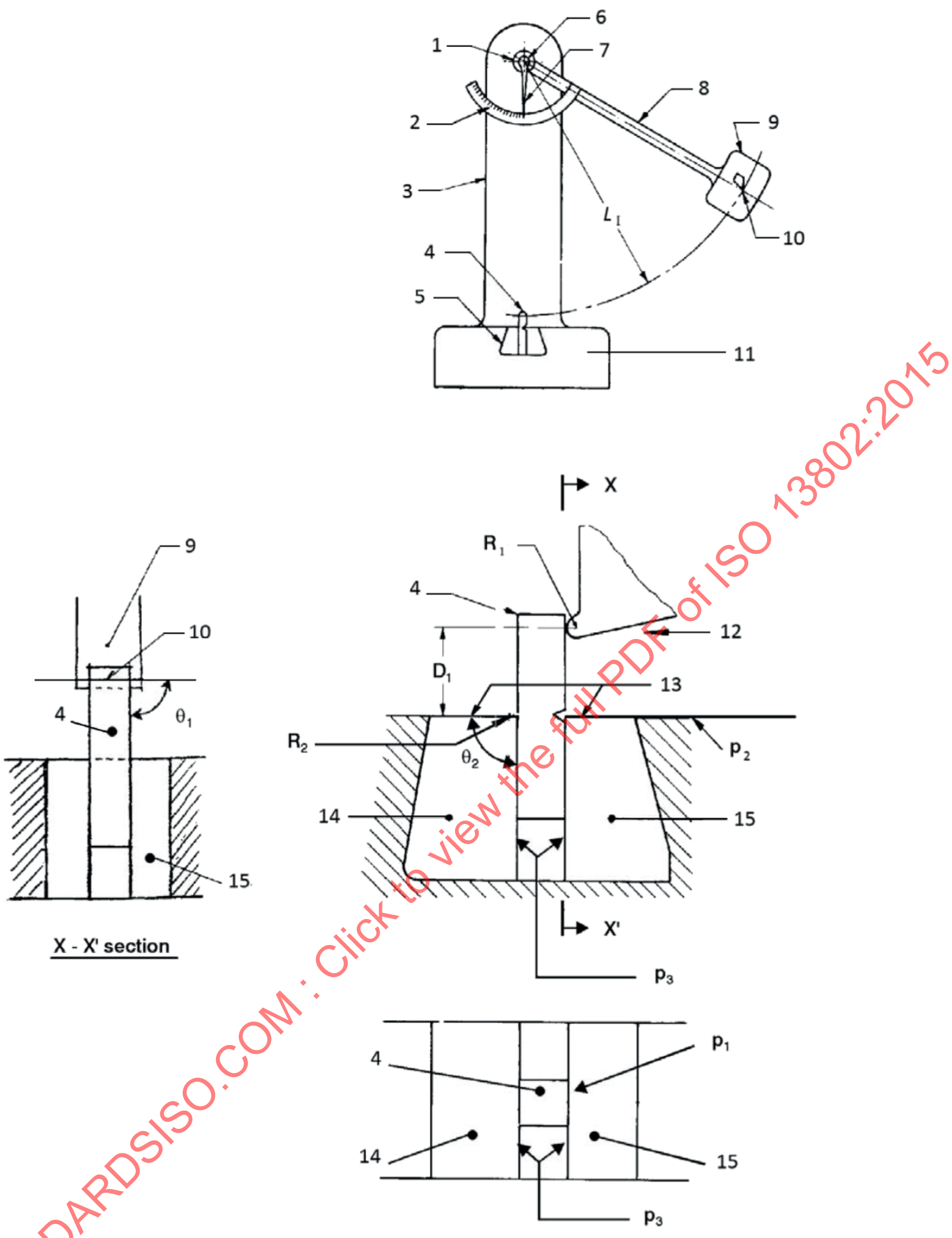
Figure A.1 — Example of Charpy test machine (for dimensions, see Table A.1)

Annex B
(normative)

Design requirements for Izod machines

Table B.1 — Properties specific to Izod machines

Parameter	Symbol used in Figure B.1	Unit	Value
Striking edge			
Radius	R_1	mm	0,8 ± 0,2
Angle relative to long axis of test specimen	θ_1	degrees	90 ± 2
Parallelism with face of reference specimen (over full width)	p_1	mm	±0,05
Frame/pendulum position			
Horizontality of top surface of vice	p_2	—	±3/1 000
Angle between lsupport block and top surface of vice	θ_2	degrees	90 ± 0,5
Location of striking edge above top surface of support	D_1	mm	22 ± 0,2
Vice faces			
Parallelism in horizontal and vertical direction	p_3	mm	±0,05
Radius of top edge of support about which bending takes place	R_2	mm	0,2 ± 0,1



Key

1	pendulum bearings	9	striker
2	scale	10	striking edge
3	frame	11	base
4	test specimen	12	direction of impact
5	vice support block and clamping block	13	top surfaces of vice
6	axis of rotation	14	support block of vice
7	friction pointer	15	clamping block of vice
8	pendulum arm		

NOTE The support and clamping block together form a vice.

Figure B.1 — Example of the Izod-test device (for dimensions, see Table B.1)

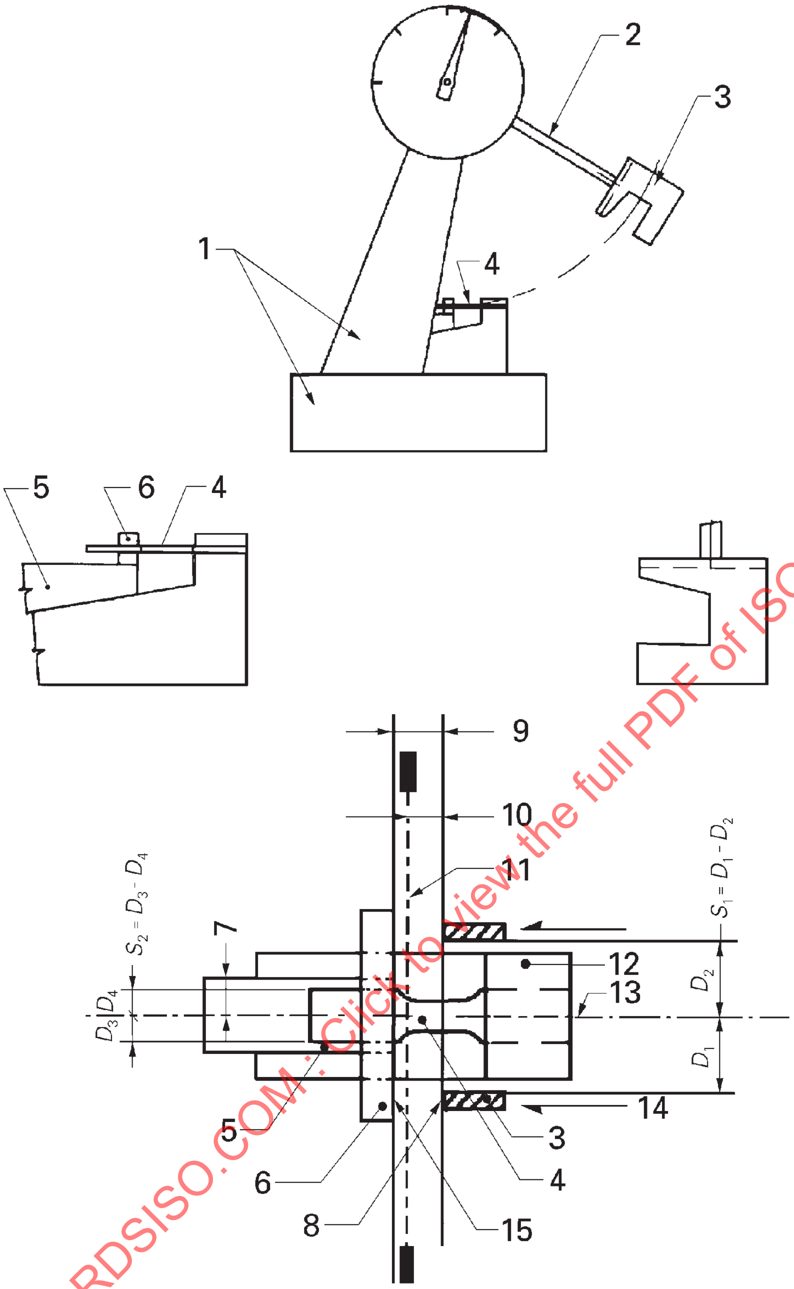
Annex C
(normative)

Design requirements for tensile impact machines

Table C.1 — Properties of tensile impact machines

Parameter	Symbol used in Figures C.1 and C.2	Unit	Value
Pendulum			
Parallelism of clamp faces with crosshead face	p_1	—	±4/1 000
Angle between clamp faces and plane of swing	p_2	degrees	90 ± 1
Symmetry of clamp faces with respect to plane of swing	S_1	mm	±0,5
Test specimen position			
Symmetry with respect to plane of swing	S_2	mm	±0,5
Angle relative to plane of swing	p_3	degrees	±0,2
Crossheads			
For mass of crosshead, see ISO 8256, Table 1.			

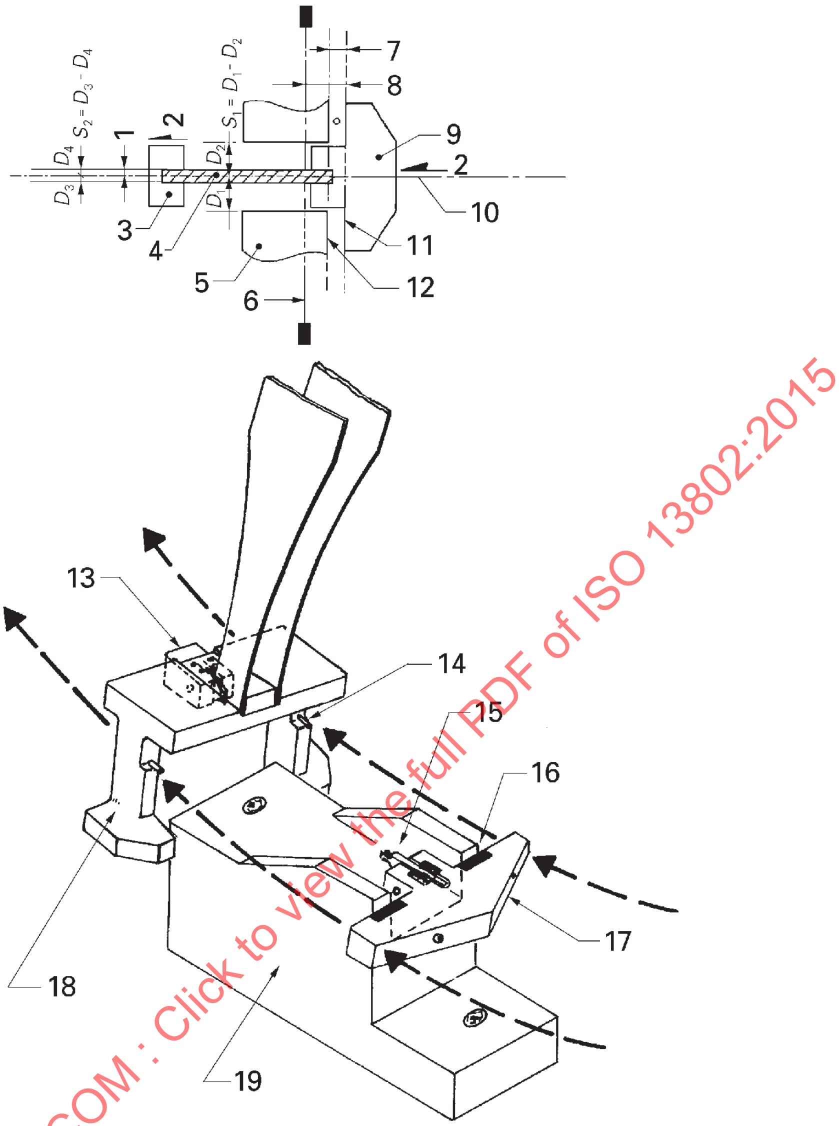
NOTE The properties of pendulum impact-testing machines which depend on the test specimen position can only be measured using tensile impact reference specimens which are exactly rectangular. Injection-moulded specimens are not suitable due to their draft angles.



Key

1	frame	9	parallelism, p_1
2	pendulum rod	10	parallelism, p_2
3	striker	11	axis of rotation
4	test specimen	12	vice jaw
5	support for crosshead	13	plane of swing
6	crosshead	14	direction of blow
7	coplanarity	15	crosshead face
8	striker face		

Figure C.1 — Diagrams showing relationship of pendulum to test specimen clamps in tensile impact test machines for use in method A of ISO 8256 (for dimensions, see Table C.1)



Key

1	coplanarity
2	direction of blow
3	pendulum head
4	test specimen
5	anvil
6	axis of rotation
7	parallelism, p_1
8	parallelism, p_2
9	crosshead clamp
10	plane of swing
11	crosshead face
12	anvil face
13	unsecured specimen clamp
14	pin for other devices for holding unsecured crosshead during downward travel
15	broken specimen
16	hardened striker pad (if necessary to prevent permanent deformation)
17	unsecured crosshead/specimen clamp
18	pendulum head
19	base
20	direction of blow
21	secure specimen clamp

Figure C.2 — Diagrams showing relationship of pendulum to test specimen clamps after test specimen rupture, for tensile impact test machines for use in method B of ISO 8256 (for dimensions, see Table C.1)

Annex D
(informative)

Ratio of frame mass to pendulum mass

The maximum value of the energy, W_F, transferred to the frame during impact can be estimated assuming that during the impact the elastically mounted frame can move freely. The period of impact is short compared with the period of oscillation, T_F, of the frame.

Neglecting the momentum of the broken specimen, the principle of conservation of momentum gives:

$$m_F v_F = m_P \left(v_I - v_A \right) \quad \text{(D.1)}$$

where

m_F is the mass of the frame, in kilograms;

m_P is the mass of the pendulum, in kilograms;

v_F is the maximum velocity of the frame just after impact, in metres per second;

v_I is the impact velocity, in metres per second;

v_A is the velocity of the pendulum just after impact, in metres per second.

Squaring Formula (D.1) and inserting the potential energy:

$$E = \frac{m_P {v_I}^2}{2}$$

and the energy uptake by the frame:

$$W_F = \frac{m_F {v_F}^2}{2}$$

gives

$$\frac{m_F}{m_P} = \frac{\left(1 - \frac{v_A}{v_I} \right)^2 E}{W_F} \quad \text{(D.2)}$$

The principle of conservation of energy gives:

$$E = \frac{m_P v_A^2}{2} + W + W_F \quad \text{(D.3)}$$

which, on rearrangement, gives

$$\frac{v_A}{v_I} = \sqrt{\frac{1 - \left(W + W_F \right)}{E}} \quad \text{(D.4)}$$

where

