INTERNATIONAL STANDARD

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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 choc-traction

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Contents

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 13802 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

Annexes A to E of this International Standard are for information only.

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

1 Scope

This International Standard specifies 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.

The test machines covered by this International Standard are of the pendulum type. The impact energy W (see 3.12) absorbed in impacting a test specimen is taken as being equal to the difference between the potential energy E (see 3.11) of the pendulum and the energy remaining in the pendulum after impacting the specimen. The impact energy is corrected for friction and air-resistance losses (see Table 2 and 5.6).

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, is being repaired, has been moved or is undergoing periodic checking.

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.

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 describes the relationships between the various characteristic pendulum lengths, the potential energy and the moment of inertia of the pendulum.

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

Annex C describes, for Charpy impact testing, the changes in pendulum velocity just after impact as a function of impact energy and gives the ranges of impact energies for the measurement of which pendulums of specified capacity have to be used.

Annex D discusses the stiffness of the base of the frame necessary to avoid resonant oscillations in the frame due to reaction forces caused by the moving pendulum.

Annex E gives the dimensions of a gauge plate suitable for the verification of Charpy impact-testing machines.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 179-2:1997, *Plastics — Determination of Charpy impact properties — Part 2: Instrumented impact test*.

ISO 180:—[2], *Plastics — Determination of Izod impact strength.*

ISO 8256:1990, *Plastics — Determination of tensile-impact strength.*

3 Definitions

For the purposes of this International Standard, the following 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, of a single complete oscillation (to and fro) of the pendulum, oscillating at angles of oscillation of less that 5° 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); it is the length of an equivalent theoretical pendulum mass concentrated at the point which gives the same period of oscillation with its T_P (3.3) as the actual pendulum

3.6
gravity length
L_M
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

[1] To be published. (Revision of ISO 179:1993)

[2] To be published. (Revision of ISO 180:1993)

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

NOTE Usually the test specimen is impacted at the lowest point of the pendulum swing (α_I = 0°). In this case, the starting 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
that 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; the mass of the frame, m_F, is expressed in kilograms

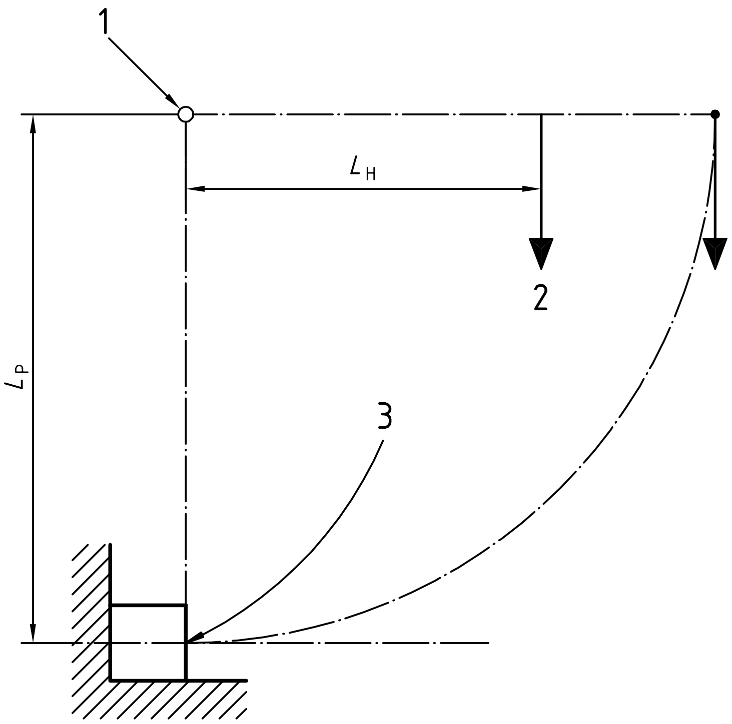
3.14
period of oscillation of the frame
T_F
period, expressed in seconds, of the freely decaying, horizontal oscillation of the frame; it characterizes the oscillation of the frame vibrating against the stiffness of the (resilient) mounting, e.g. a test bench and/or its foundation (which may include damping material for instance) (see annex D)

3.15
mass of the pendulum
$m_{P,max}$
mass, expressed in kilograms, of the heaviest pendulum used

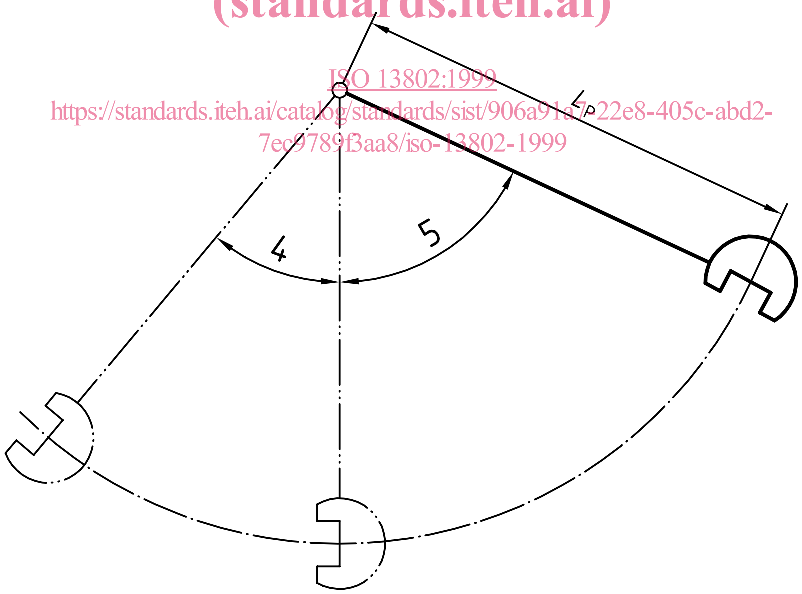
4 Measurement instruments

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 5.



a) Quantities necessary to determine the horizontal moment



b) Quantities necessary for scale calibration and for potential-energy calculations

Key

1 Axis of rotation
2 Vertical force, F_H
3 Centre of percussion
4 Angle of rise, α_R
5 Starting angle, α_0

Figure 1 — Quantities necessary for energy verification

5 Verification of test machines

5.1 Components of test machines

The essential components are as follows:

5.1.1 Pendulum

5.1.1.1 Pendulum rod.

5.1.1.2 Striker, with striking edge for bending impact tests (see ISO 179 and ISO 180) or with striking surfaces or clamps for tensile impact testing (see ISO 8256:1990, test methods A and B respectively).

5.1.2 Frame

5.1.2.1 Test specimen supports, for Charpy impact testing (see ISO 179);

5.1.2.2 Vice, for Izod impact testing (see ISO 180);

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

5.1.2.4 Mechanism for holding and releasing the pendulum.

5.1.3 Energy indicating device

5.1.4 Crossheads for tensile impact testing

5.2 Pendulum

5.2.1 Pendulum length, L_P

Determine the pendulum length L_P from the period of oscillation T_P of the pendulum using the equation

$$L_P = \frac{gT_P^2}{4\pi^2} \quad (1)$$

where

g is the local acceleration due to gravity, in metres per second squared;

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

The value of T_P shall be determined to a precision of 0,2 %.

Determine the period of oscillation T_P as the mean value of four determinations, of total duration $n \cdot T_P$, of n consecutive oscillations to an accuracy of 0,1 s. Together with the precision demanded above of L_P, this results in a minimum number n of oscillation given by $n \geqslant 100/T_P$.

The use of a timing device accurate to better than 0,1 s allows the number of oscillations to be reduced accordingly (see Table 1).

Table 1 — 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 0,01	105 11
0,390	1,25	0,1 0,01	80 8

5.2.2 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 equation (1) and Figure 1a)].

5.2.3 Potential energy, E

The potential energy E shall not differ by more than ± 1 % from the nominal value given in the first column of Table 2.

Determine the potential energy by the following procedure, or by any other method capable of determining the initial potential energy of the pendulum to within the precision specified above.

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 ± 0,2 %.

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

$$M_H = F_H L_H \tag{2}$$

d) Measure the starting 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 equation:

$$E = M_H(\cos\alpha_I - \cos\alpha_0) \tag{3}$$

where

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

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

α_0 is the starting 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 α_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

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	Tensile		1
4,0	Tensile		0,5
5,0	Charpy		0,5
7,5	Tensile	3,8 (± 10 %)	0,5
15	Tensile		
25	Tensile		
50	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

5.2.4 Impact velocity, v_I

5.2.4.1 Value

The impact velocity v_I shall have the value given in Table 2 for Charpy, Izod and tensile impact testing, respectively.

5.2.4.2 Determination

Determine the impact velocity using the equation:

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

where

v_I is the impact velocity, in metres per second;

g is the local acceleration due to gravity, in metres per second squared;

L_I is the impact length (see 5.2.2), in metres;

α_0 is the starting angle, in degrees;

α_I is the impact angle, in degrees (see note 1 to 5.2.3).

5.2.5 Types of pendulum impact-testing machine

Three different types of test machine are covered by this International Standard.

Figure 2 shows a typical example of a Charpy test machine. Important values to be verified are listed in Table 3.

Figure 3 shows a typical example of an Izod test machine. Important values to be verified are listed in Table 4.

Figures 4 and 5 show typical examples of tensile impact-testing machines. Important values to be verified are listed in Table 5.

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

Table 3 — Properties of Charpy machines

Parameter	Symbol used in Figure 2	Unit	Value
Pendulum			
Angle of striker tip	θ_1	degrees	30 ± 1
Radius of striking edge	R_1	mm	2 ± 0,5
Frame/pendulum position			
Parallelism between long axis of test specimen and reference plane (if present)	p_1	—	± 4/1 000
Distance between striking edge and centre of gravity of striker	D_1	mm	± 0,5
Position of midplane between supports, relative to striking edge	D_2	mm	± 0,5
Test specimen supports			
Radius of curvature of supports	R_2	mm	1 ± 0,1
Angle of taper of supports	θ_2	degrees	10 ± 1
Angle of slope of supports	θ_3	degrees	5 ± 1
Angle of supports	θ_4	degrees	90 ± 0,1

Table 4 — Properties of Izod machines

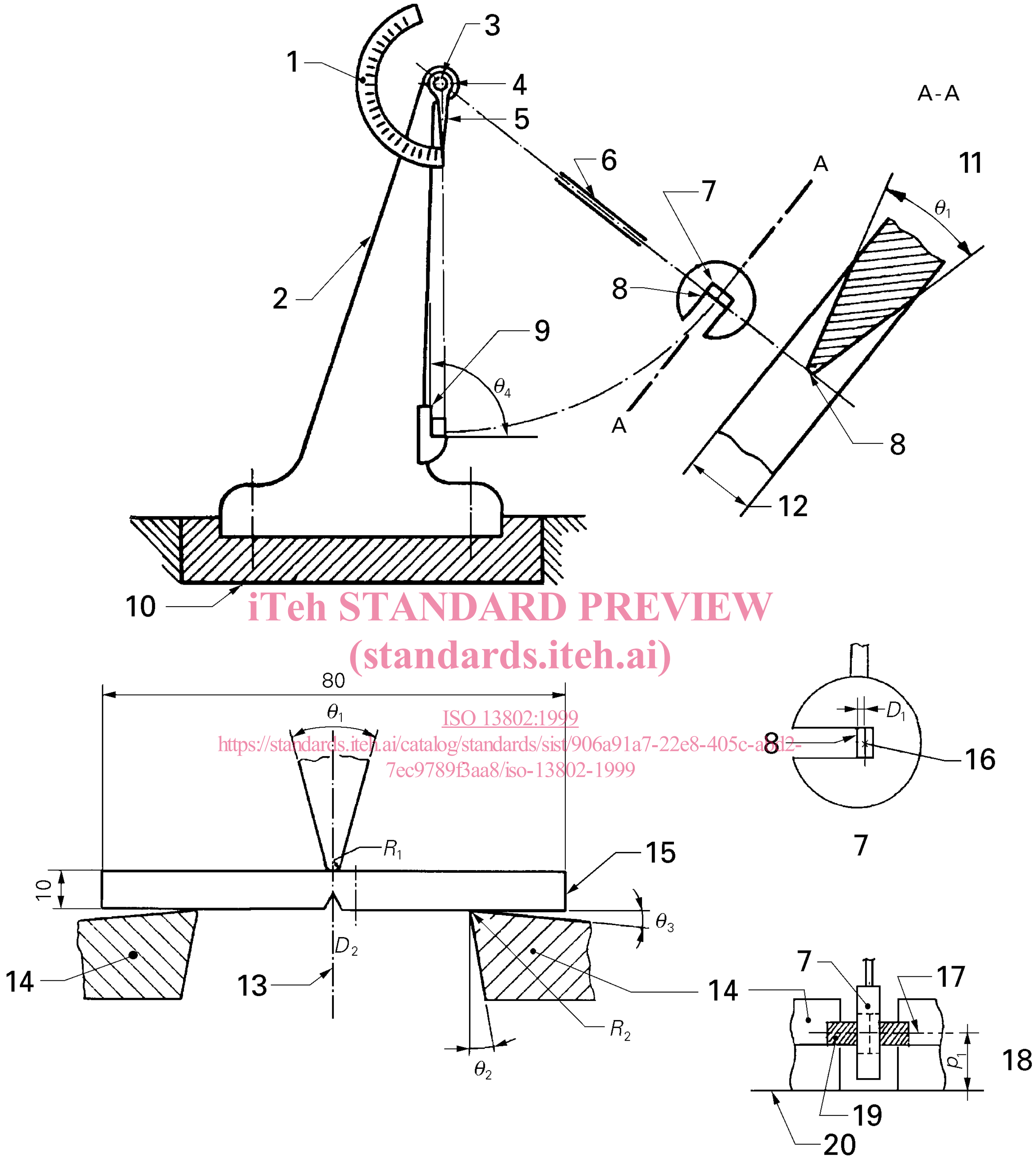
Parameter	Symbol used in Figure 3	Unit	Value
Striking edge			
Radius	R_1	mm	0,8 ± 0,2
Angle relative to long axis of test specimen	θ_1	degrees	90 ± 2
Parallelism with face of test specimen (over full width)	p_1	mm	± 0,025
Frame/pendulum position			
Horizontality of top surface of vice	p_2	—	± 3/1 000
Angle between locating groove 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	± 0,025
Radius of top edge of support about which bending takes place	R_2	mm	0,2 ± 0,1

Table 5 — Properties of tensile impact machines

Parameter	Symbol used in Figures 4 and 5	Unit	Value
Pendulum			
Parallelism of striker/anvil faces with crosshead face	p_1	—	± 4/1 000
Angle between striker/anvil faces and plane of swing	p_2	degrees	90 ± 1
Symmetry of striker/anvil 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 8256:1990, Table 1			

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

Dimensions in millimetres



Key

1 Scale
2 Machine frame
3 Axis of rotation
4 Pendulum bearings
5 Friction pointer
6 Pendulum rod
7 Striker
8 Striking edge
9 Test specimen supports
10 Foundation
11 Included angle of striker, θ_1
12 Width of striker
13 Plane of symmetry of supports
14 Support
15 Standard test specimen
16 Centre of gravity of striker
17 Axis of test specimen
18 Parallelism, p_1
19 Test specimen
20 Reference plane

Figure 2 — Details of Charpy test machine (for dimensions, see Table 3)