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Metallic materials — Charpy pendulum impact test —

Part 2:
Verification of test machines

Matériaux métalliques — Essai de flexion par choc sur éprouvette Charpy —

Partie 2: Vérification des machines d'essai (mouton-pendule)

ISO 148-2:1998(E)

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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.

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 148-2 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 4, *Toughness testing*.

It cancels and replaces Recommendation ISO/R 442:1965, which has been technically revised.

ISO 148 consists of the following parts, under the general title *Metallic materials — Charpy pendulum impact test*:

— *Part 1: Test method*

— *Part 2: Verification of test machines*

— *Part 3: Preparation and characterization of Charpy V reference test pieces for verification of test machines*

Metallic materials — Charpy pendulum impact test —

Part 2:
Verification of test machines

1 Scope

This part of ISO 148 covers the verification of the constructional elements of pendulum-type impact testing machines. It is applicable to machines with 2 mm or with 8 mm strikers used for pendulum impact tests carried out, for instance, in accordance with ISO 148-1.

It can analogously be applied to pendulum impact testing machines of other capacities and of different design.

Impact machines used for industrial, general or research laboratory testing of metallic materials in accordance with this part of ISO 148 are referred to as industrial machines. Those with more stringent requirements are referred to as reference machines. Specifications for the verification of reference machines are found in ISO 148-3.

This part of ISO 148 describes two methods of verification.

a) The direct method which is static in nature and involves measurement of the critical parts of the machine to ensure that it meets the requirements of this part of ISO 148. The verification equipment shall have a certified traceability to the International Unit System. The direct method shall be used when a machine is being installed or repaired, or if the indirect method gives an incorrect result.

b) The indirect method, which is dynamic in nature, and which use reference test pieces to verify points on the measuring scale.

A pendulum impact testing machine is not in compliance with this part of ISO 148 until it has been verified by both the direct and indirect methods (see clause 12).

The requirements for the reference test pieces are found in ISO 148-3.

NOTE — This part of ISO 148 takes into account the total energy absorbed in fracturing the test piece using an indirect method. This total absorbed energy consists of 1) the energy needed to break the test piece itself and 2) the internal energy losses of the pendulum impact testing machine performing the first half-cycle swing from the initial position. Internal energy losses are due to:

a) Air resistance, friction of the bearings of the rotation axis and the indicating pointer of the pendulum which can be determined by the direct method (see 9.4).

b) Shock of the foundation, vibration of the frame and pendulum for which no suitable measuring methods and apparatus have been developed.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 148. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 148 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 148-1:—[1]), *Metallic materials — Charpy pendulum impact test — Part 1: Test method.*

ISO 148-3:1998, *Metallic materials — Charpy pendulum impact test — Part 3: Preparation and characterization of Charpy V reference test pieces for verification of test machines.*

3 Definitions

For the purposes of this part of ISO 148, the following definitions apply.

3.1 Definitions pertaining to the machine

3.1.1 anvil: The portion of the base of the machine forming a vertical plane which restrains the test piece when it is struck by the pendulum (see figures 1 to 3), the plane of the supports being perpendicular to the plane of the anvil.

3.1.2 base: That part of the framework of the machine located below the horizontal plane of the supports.

3.1.3 centre of percussion: That point in a body at which, on striking a blow, the percussive action is the same as if the whole mass of the body was concentrated at the point (see figure 4).

NOTE — When a simple pendulum delivers a blow along a horizontal line passing through the center of percussion, there is no resulting horizontal reaction at the axis of rotation.

3.1.4 centre of strike: That point on the striking edge of the pendulum at which, in the free hanging position of the pendulum, the vertical edge of the striker meets the upper horizontal plane of a test piece of half standard height (i.e. 5 mm) or equivalent gauge bar resting on the test piece supports (see figure 2).

3.1.5 industrial machine: Impact machine used for industrial, general, or most research-laboratory testing of metallic materials. These machines are not used to establish reference values. Industrial machines are verified using the procedures described in this part of ISO 148.

3.1.6 reference machine: Pendulum impact testing machines used to determine the reference energy of a reference test piece. The verification requirements for this grade of machine are more stringent than those for industrial machines and are contained in ISO 148-3.

3.1.7 striker: The portion of the hammer that contacts the test piece. The edge that actually contacts the test piece may have a radius of 2 mm (the 2 mm striker) or a radius of 8 mm (the 8 mm striker). (See figure 2.)

3.1.8 test piece supports: The portion of the base of the machine forming a horizontal plane upon which the test piece rests prior to being struck by the hammer (see figures 2 and 3). The plane of the supports is perpendicular to the plane of the anvil.

3.2 Definitions pertaining to energy

3.2.1 actual absorbed energy (absorbed energy), A_V**:** The total energy required to break a test piece when tested by a pendulum impact testing machine. It is equal to the difference in the potential energy from the starting position of the pendulum to the end of the first half swing during which the test piece is broken (see clause 9).

3.2.2 actual initial potential energy (potential energy), A_P**:** The value determined by direct verification (see clause 9.1).

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1) To be published. (Revision of ISO 83:1976 and ISO 148:1983)

3.2.3 indicated absorbed energy (indicated energy), A_S**:** The energy value indicated by the pointer or other readout device.

3.2.4 nominal initial potential energy (nominal energy), A_N**:** The energy assigned by the manufacturer of the pendulum impact testing machine.

3.2.5 reference energy, A_R**:** The absorbed energy value associated with reference test pieces, determined from tests made using reference machines.

3.3 reference test pieces: Impact test pieces used to verify the suitability of an industrial grade, pendulum impact testing machine by comparing the indicated energy measured by that machine to the reference energy associated with the test pieces. Reference test pieces are prepared in accordance with ISO 148-3.

3.4 Definitions pertaining to test pieces (placed in the test position on the supports of the machine) (see figures 2 and 3)

3.4.1 height: Distance between the notched face and the opposite face.

3.4.2 width: Dimension perpendicular to the height that is parallel to the notch.

3.4.3 length: Largest dimension at right angles to the notch.

4 Symbols

For the purposes of this part of ISO 148, the symbols and designations in table 1 are applicable.

Table 1 — Symbols and their meanings

Symbol (see figure 4)	Unit	Meaning
A_N	J	Nominal initial potential energy (nominal energy)
A_P	J	Actual initial potential energy (potential energy)
A_R	J	Reference energy of a set of Charpy reference test pieces
A_S	J	Indicated absorbed energy (indicated energy)
A_V	J	Actual absorbed energy (absorbed energy)
E_1 or β_1	J or degree	Indicated energy or angle of rise when the machine is operated in the normal manner without a test piece in position
E_2 or β_2	J or degree	Indicated energy or angle of rise when the machine is operated in the normal manner without a test piece in position and without resetting the indication mechanism
E_3 or β_3	J or degree	Indicated energy or angle of rise after 11 half swings when the machine is operated in the normal manner without a test piece in position and without resetting the indication mechanism
F	N	Force exerted by the pendulum when measured at a distance of l_2
h	m	Height of fall of pendulum
h_1	m	Height of rise of pendulum
l	m	Distance to centre of test piece (centre of striker) from the axis of rotation (length of pendulum)
l_1	m	Distance to the centre of percussion from the axis of rotation
l_2	m	Distance to the point of application of the force F from the axis of rotation
M	N·m	The moment equal to the product Fl_2

Table 1 — Symbols and their meanings *(end)*

Symbol (see figure 4)	Unit	Meaning
p	J	Energy loss caused by pointer friction
p'	J	Energy loss caused by bearing friction and air resistance
p_β	J	Correction of energy losses for an angle of swing β
t	s	Period of the pendulum
T	s	Total time for 100 swings of the pendulum
T_{max}	s	Maximum value of T
T_{min}	s	Minimum value of T
W	N	Weight of the pendulum
α	degree	Angle of fall of the pendulum
β	degree	Angle of rise of the pendulum

5 Testing machine

A pendulum impact testing machine consists of the following parts (see figures 1 to 3):

a) foundation/installation;

b) machine framework — the structure supporting the pendulum, excluding the foundation;

c) pendulum including the hammer;

d) anvils and supports (see figures 2 and 3);

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

6 Verification

The verification of the machine can occur only after installation and involves the inspection of the following items:

a) foundation/installation;

b) machine framework;

c) pendulum, including the hammer and the striker;

d) anvils and supports;

e) indicating equipment.

7 Foundation/installation

The foundation to which the machine is fixed and the method(s) of fixing the machine to the foundation are of utmost importance.

7.1 Inspection of the machine foundation usually cannot be made once the machine has been installed, thus documentation made at the time of installation must be produced to provide assurance that the mass of the foundation is not less than 40 times that of the pendulum.

7.2 Inspection of the installed machine shall consist of the following.

a) Ensuring that the bolts are torqued to the value specified by the machine manufacturer. The torque value shall be noted in the document provided by the manufacturer of the machine (see 7.1). If other mounting arrangements are used or selected by an end user, equivalency must be demonstrated.

b) Ensuring that the machine is not subject to external vibrations transmitted through the foundation at the time of the impact test.

NOTE — This can be accomplished, for example, by placing a small container of water on any convenient location on the machine framework. Absence of ripples on the water surface indicates that this requirement is met.

8 Machine framework

Inspection of the machine framework (see figure 1) shall consist of determining the following items:

a) free position of the pendulum;

b) location of the pendulum in relation to the supports;

c) transverse and radial play of the pendulum bearings;

d) clearance between the hammer and the framework.

Machines manufactured after the original publication date of this part of ISO 148 shall have a reference plane from which measurements can be made.

8.1 The axis of rotation of the pendulum shall be parallel to the reference plane to within 2/1 000. This shall be certified by the manufacturer.

8.2 The machine shall be installed so that the reference plane is horizontal to within 2/1 000.

For pendulum impact testing machines without a reference plane, the axis of rotation shall be established to be horizontal to within 4/1 000 directly or a reference plane shall be established from which the horizontality of the axis of rotation can be verified as described above.

8.3 When hanging free, the pendulum shall hang so that the striking edge is within 0,5 mm of the position where it would just touch the test specimen.

NOTE — This condition can be determined using a gauge in the form of a bar, approximately 55 mm in the length and of rectangular section, 9,5 mm in height and approximately 10 mm in width (see figure 3). The distance between the striker and the bar is then measured.

8.4 The plane of the swing of the pendulum shall be $90^\circ \pm 0,1^\circ$ (3/1 000) to the axis of rotation.

8.5 The striker shall make contact over the full width of the test piece.

NOTE — One method of verifying this is as follows. A test piece having dimensions of 55 mm × 10 mm × 10 mm is tightly wrapped in thin paper (e.g. by means of adhesive tape), and the test piece is placed in the test-piece supports. 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 test piece, and prevented from contacting the test piece a second time. The mark made by the carbon paper on the paper covering the test piece 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 test piece (9.7).

8.6 The pendulum shall be located so that the centre of the striker and the centre of the gap between the anvils are coincident to within 0,5 mm.

8.7 Axial play in the pendulum bearings shall not exceed 0,25 mm measured at the striker under a transverse force of approximately 4 % of the effective weight of the pendulum, W [see figure 4 b)], applied at the centre of strike.

8.8 Radial play of the shaft in the pendulum bearings shall not exceed 0,08 mm, when a load of 150 N ± 10 N is applied at a distance L at right angles to the plane of swing of the pendulum.

NOTE — The radial play can be measured, for example, by a dial gauge mounted on the machine frame at the bearing housing, in order to indicate movement at the end of the shaft (in the bearings) when a force of about 150 N is applied to the pendulum perpendicularly to the plane of the swing.

8.9 For new machines, it is recommended that the mass of the base of the machine framework should be at least 12 times that of the pendulum.

NOTE — The base of the machine is that portion of the framework located below the plane(s) of the supports.

9 Pendulum

The verification of the pendulum (including striker) should consist of determining the following quantities:

a) potential energy, A_P;

b) error in the indicated energy, A_S;

c) velocity of the pendulum at instant of impact;

d) energy absorbed by friction;

e) position of centre of percussion (i.e. distance from centre of percussion to axis of rotation);

f) type of striker and

   1) radius of curvature of the tip of the striker;

   2) angle of tip of striker;

g) angle of the line of contact of the striker and the horizontal axis of the test piece.

9.1 The potential energy, A_P, shall not differ from the nominal energy, A_N, by more that ± 1 %. The potential energy A_P shall be determined as follows:

The moment of the pendulum is determined by supporting the pendulum at a chosen distance, l_2, from the axis of rotation by means of a knife edge on a balance or dynamometer in such a manner that the line through the axis of rotation which joins the centre of gravity of the pendulum is horizontal within 15/1 000 [see figure 4 a)].

The force, F, and the length, l_2, shall each be determined to an accuracy of ± 0,2 %. The moment, M, is the product $F \times l_2$.

NOTE 1 Length l_2 can be equal to length l.

The angle of fall, α, shall be measured to an accuracy of ± 0,4°; this angle can be greater than 90°.

The potential energy, A_P, is then calculated by the following formula

$$A_P = M(1 - \cos\alpha)$$

NOTE 2 This formula and subclauses 9.2 to 9.4 relate to machines having indicators which measure the angle of fall and of rise of the pendulum. For machines that have other indicating devices, the procedures should be modified appropriately.

9.2 The graduation marks on the scale corresponding approximately to values of absorbed energy of 0 %, 10 %, 20 %, 30 %, 50 % or 60 %, and 80 % of the nominal energy shall be verified.

For each of these graduation marks, the pendulum shall be supported so that the graduation mark is indicated by the pointer, and the angle of rise, β, then determined to ± 0,4°. The absorbed energy is given by the formula

$$A_V = M(\cos\beta - \cos\alpha)$$

NOTE 1 The degree of inaccuracy of measurement of l_2, F and β as specified yields a mean total error of measurement of A_V of approximately ± 0,3 % of the full-scale value.

The difference between the indicated energy, A_S, and the absorbed energy, A_V, calculated from the measured values, shall not be greater than ± 1 % of the absorbed energy, A_V, or ± 0,5 % of the potential energy, A_P. In each case, the greater value is permitted, i.e.:

$$\left|\frac{A_S - A_V}{A_V}\right| \times 100 \leqslant 1\ \%$$ at between 80 % and 50 % of the nominal energy, A_N

$$\left|\frac{A_S - A_V}{A_P}\right| \times 100 \leqslant 0{,}5\ \%$$ at less than 50 % of the nominal energy, A_N

NOTE 2 Attention is drawn to the fact that the accuracy of the absorbed energy reading varies inversely to its value, and this should be borne in mind when A_V is small in comparison with A_P.

Absorbed energy values greater than 80 % of the potential energy are inaccurate and should be reported as approximate.

NOTE 3 This requirement is to ensure that all tests are conducted at strain rates that vary by less than a factor of 2. The strain rate is a function of the velocity of the pendulum while the striker is in contact with the specimen; for a pendulum impact testing machine, the velocity decreases as the fracture progresses. The change in the velocity of the pendulum can be calculated by first determining the velocity at impact using the formula in 9.3 and after impact using the same formula except that the cosine of β is substituted for the cosine of α (see figure 4).

9.3 The velocity at impact should be determined from the formula

$$v = \sqrt{2gl(1 - \cos\alpha)}$$

where

l is the distance from the axis of rotation of the pendulum to the centre of the test piece;

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

α is the angle of fall (see figure 4).

The velocity at impact should be 5 m/s to 5,5 m/s; however, for machines manufactured prior to the publication of this part of ISO 148, any value within the range of 3 m/s to 6 m/s is permissible and the value shall be stated in the report.

9.4 The energy absorbed by friction includes air resistance, bearing friction and the friction of the indicating pointer. These losses shall be estimated as follows.

9.4.1 To determine the loss caused by pointer friction, the machine is operated in the normal manner, but without a test piece in position, and the angle of rise, β_1, or energy reading E_1, noted as indicated by the pointer. A second