
**Resistance spot welding and projection
welds — Destructive testing of welds —
Specimen dimensions and procedure for
impact shear test and cross-tension
testing**

*Soudage par résistance par points et par bossages — Essais
destructifs des soudures — Dimensions des éprouvettes et procédure
d'essai de cisaillement par choc et d'essai de traction par choc sur
éprouvettes en croix*

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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 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 14323 was prepared by the International Institute of Welding, recognized as an international standardizing body in the field of welding in accordance with Council Resolution 42/1999.

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Introduction

Requests for official interpretations of provisions in this standard should be made in writing and sent to the ISO Central Secretariat who will forward them to the IIW Secretariat for an official response.

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Resistance spot welding and projection welds — Destructive testing of welds — Specimen dimensions and procedure for impact shear test and cross-tension testing

1 Scope

This International Standard covers destructive testing of welds.

This International Standard specifies specimen dimensions and testing procedures for impact shear and cross-tension testing of resistance spot and embossed projection welds in overlapping sheets, in any metallic material of thickness 0,5 mm to 4 mm.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 669, *Resistance welding — Resistance welding equipment — Mechanical and electrical requirements*

ISO 14272, *Specimen dimensions and procedure for cross tension testing resistance spot and embossed projection welds*

ISO 14329, *Resistance welding — Destructive tests of welds — Failure types and geometric measurements for resistance spot, seam and projection welds*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 669 and ISO 14329 and the following apply.

3.1

corona bond

area of the weld at the faying surfaces in which solid-phase bonding has occurred

3.2

impact cross-tension failure energy

failure energy measured in the impact cross-tension test

3.3

impact cross-tension force

maximum force measured in the impact cross-tension test

3.4

impact shear failure energy

failure energy measured in the impact shear test

3.5

impact shear force

maximum force measured in the impact shear test

3.6

interface failure

fracture through the weld (nugget) between the sheets at the plane of the interface

See Figure 1 b).

3.7

nominal weld diameter

diameter of the plug (slug/button) measured at the base of the nugget

See Figure 1 a).

3.8

plug failure

slug/button failure

fracture in the base metal, the heat-affected zone, or in the nugget leaving a plug

See Figure 1 a).

3.9

weld diameter

d

⟨interface failure⟩ diameter of the fused zone measured at the interface, omitting the corona bond area

See Figure 1 b).

3.10

weld diameter

d

⟨partial plug failure⟩ mean diameter of the fused zone measured at the interface, omitting the corona bond area and the maximum diameter of the plug component of the failure

NOTE The minimum diameter of the plug component should be quoted separately [see Figure 1 a) and b)].

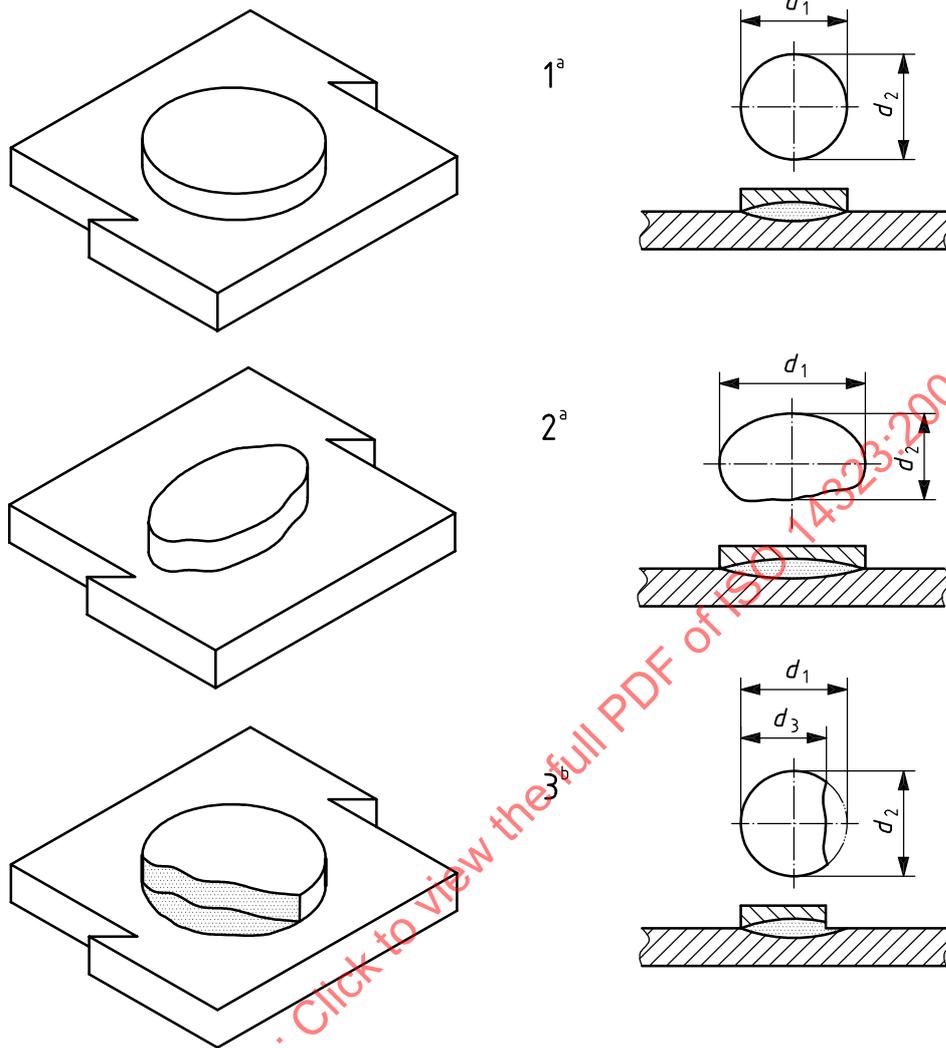
3.11

weld diameter

d

⟨plug failure⟩ average diameter of the plug

See Figure 1 a).



Key

- 1 symmetrical
- 2 asymmetrical
- 3 partial

^a $d = d_p = (d_1 + d_2)/2$

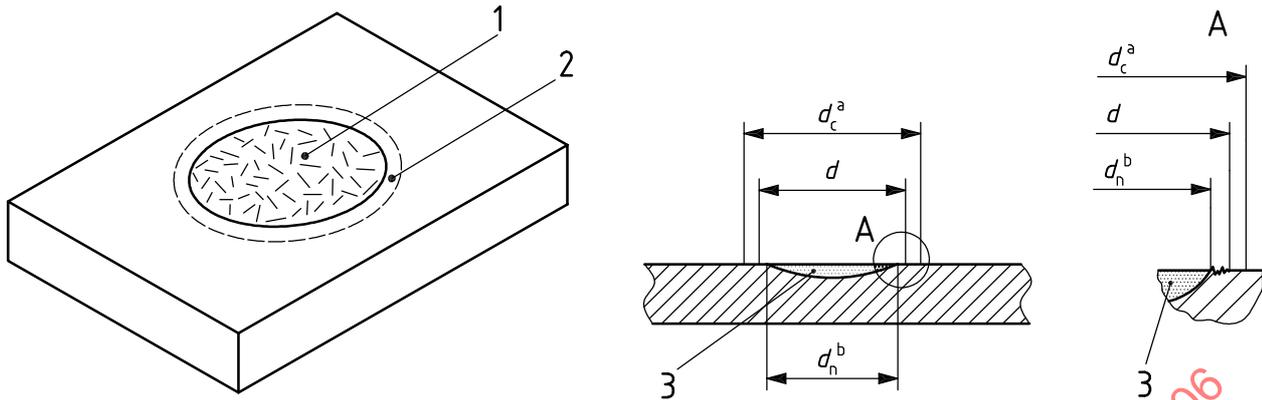
^b $d = (d_1 + d_2)/2$ and
 $d_p = (d_2 + d_3)/2$

where

- d_p is the mean plug diameter;
- d_1 is the maximum weld diameter;
- d_2 is the minimum weld diameter;
- d_3 is the minimum width of plug.

a) Weld with plug (slug) failure

Figure 1 — Measuring weld diameter



Key

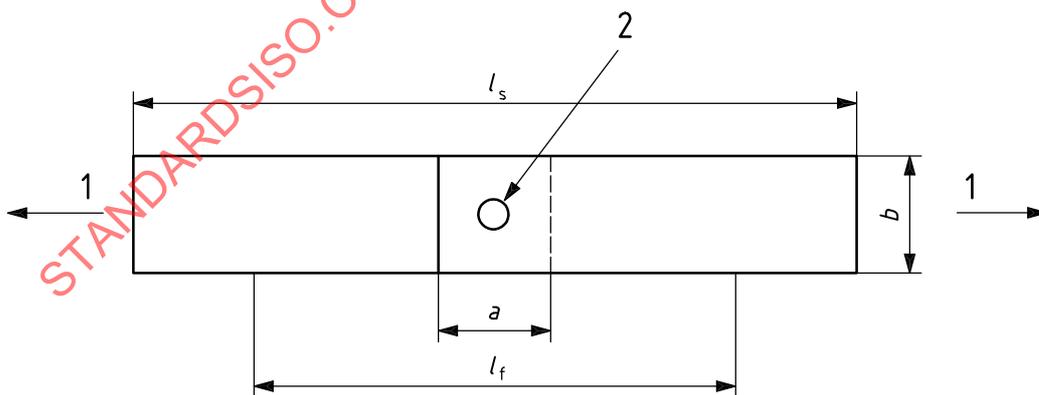
- 1 sheared nugget
 - 2 corona bond zone
 - 3 nugget
- a Diameter of the corona.
 b Diameter of the nugget.

b) Weld with interface failure, $d < d_c$

Figure 1 (continued)

4 Test specimen

Dimensions and form of the impact shear test specimen are shown in Figure 2 and Table 1. Dimensions and form of the impact cross-tension specimen are shown in Figure 3 (see ISO 14272). An example of a jig for welding the cross-tension specimen is shown in Figure 4. Two punched strips are placed at right angles to each other, held in the jig, and welded together.



Key

- 1 direction of test load
- 2 weld

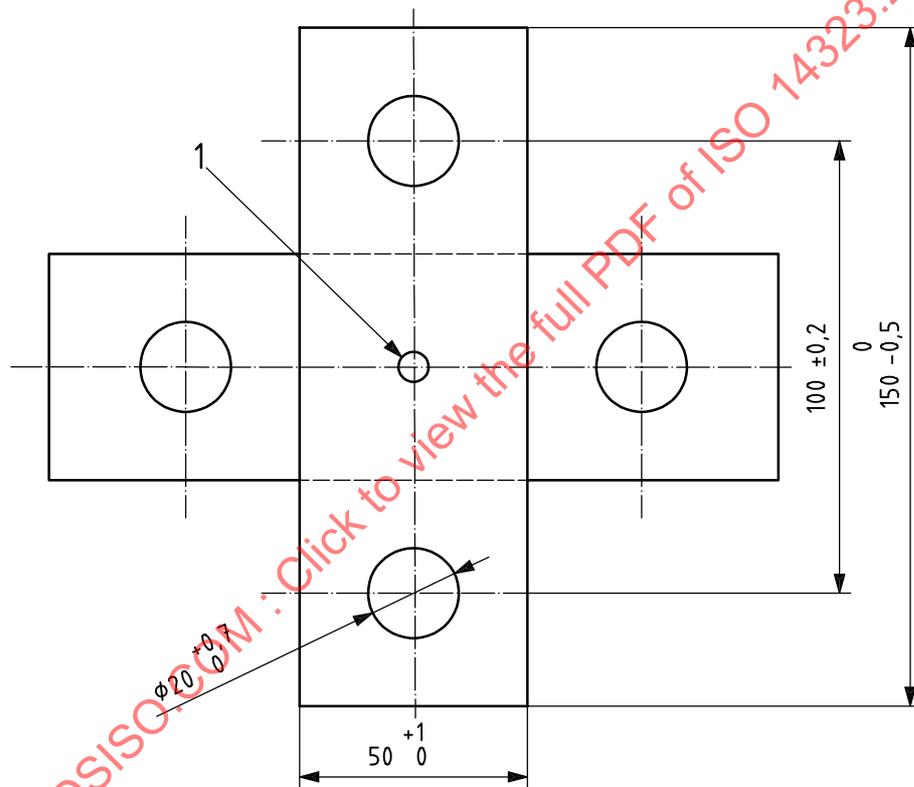
Figure 2 — Form of impact shear test specimen

Table 1 — Dimensions of impact shear test specimens

Dimensions in millimetres

Sheet thickness t	Overlap a	Width b	Length l	Overall length l_s	Unclamped length l_f
$0,5 \leq t \leq 1,5$	35	45	105	175	95
$1,5 < t \leq 3,0$	45	60	138	230	105
$3,0 < t \leq 4,0$	60	90	160	260	120

Dimensions in millimetres

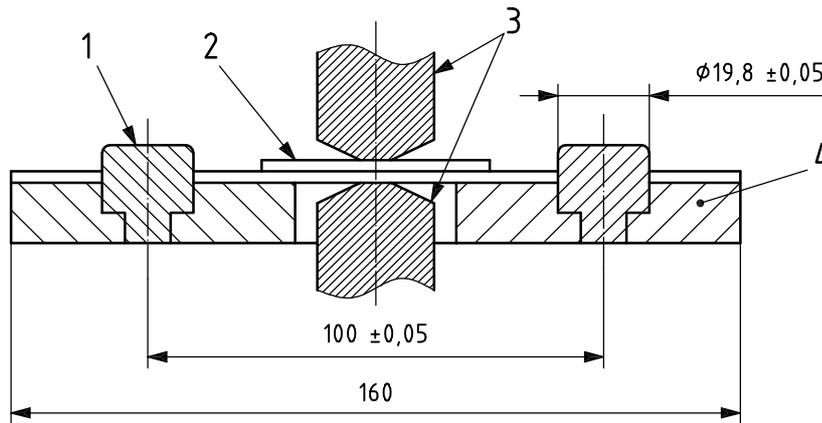


Key

- 1 weld is centred

Figure 3 — Form of impact cross-tension test specimen

Dimensions in millimetres



Key

- 1 location pins
- 2 specimen
- 3 welding electrodes
- 4 insulating materials

Figure 4 — Example of cross-tension test specimen in a welding jig

5 Test equipment and testing procedure

5.1 General

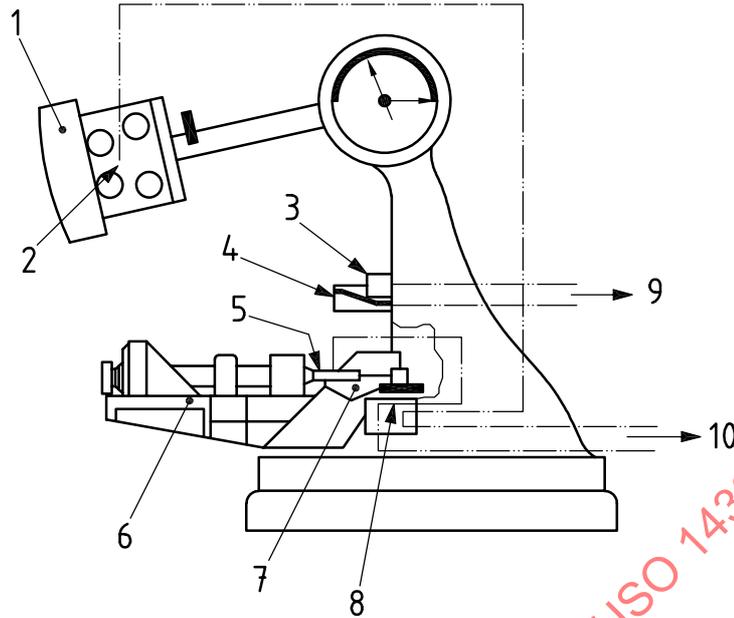
Testing can be accomplished with an appropriate impact-testing machine. The minimum number of specimens tested shall be five.

NOTE 1 The pendulum-type machine is generally used for a sheet thickness range of 0,5 mm to 3 mm, and the drop-weight machine for a sheet thickness range of 1 mm to 4 mm.

NOTE 2 If needed, the load can be obtained using hydraulic test equipment.

5.2 Modified pendulum machine

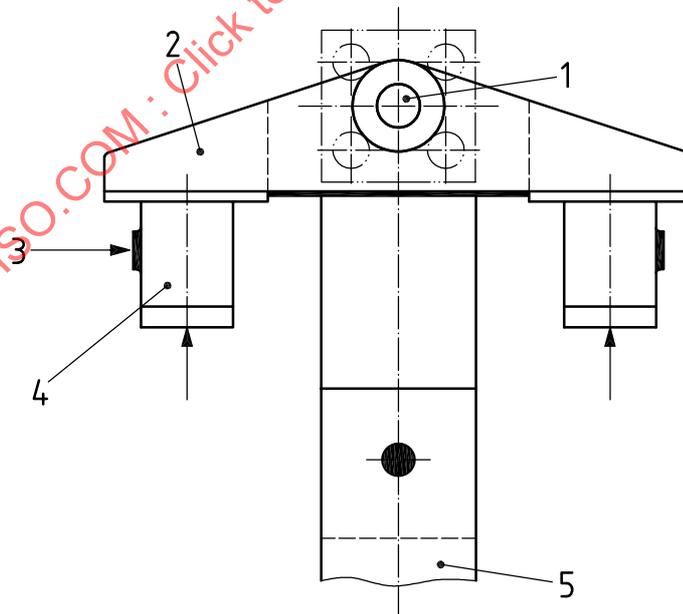
The test specimen is fixed between the clamping device and the crosshead using the equipment shown in Figures 5 and 6. A U-shaped hammer shall be used for testing and is attached to the pendulum. At the bottom of the pendulum swing, the hammer strikes the crosshead. The energy to failure is indicated by the extent of the upward swing of the pendulum. The velocity of the pendulum at the time of impact is 5,5 m/s. To measure impact force, strain gauges attached to the clamping device or an appropriate load cell shall be used (see Figures 5 and 6). The absorbed energy is determined as a function of time (see Annex A).



Key

- | | |
|--------------------------|-------------------|
| 1 hammer | 6 clamping device |
| 2 strain gauge/load cell | 7 test specimen |
| 3 lamp | 8 cross head |
| 4 photodiode | 9 power supply |
| 5 strain gauge | 10 amplifier |

Figure 5 — Pendulum machine with U-shaped hammer, equipped for testing spot-welded impact shear specimens



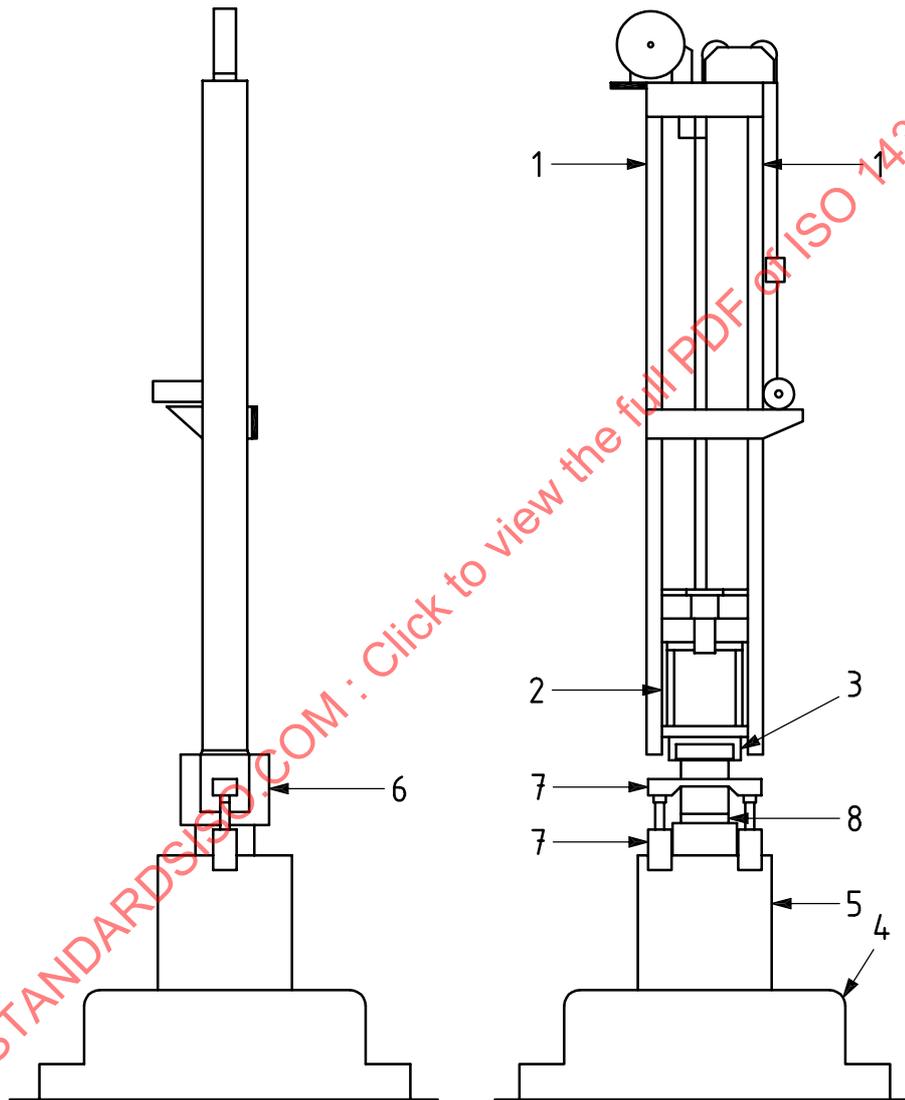
Key

- | |
|---|
| 1 pivot (maximum rotation 2°) |
| 2 cross head (introduce load into test piece) |
| 3 strain gauge |
| 4 impact part of the hammer |
| 5 fixed part of the specimen |

Figure 6 — Impact shear test specimen and details of cross head

5.3 Drop-weight machine

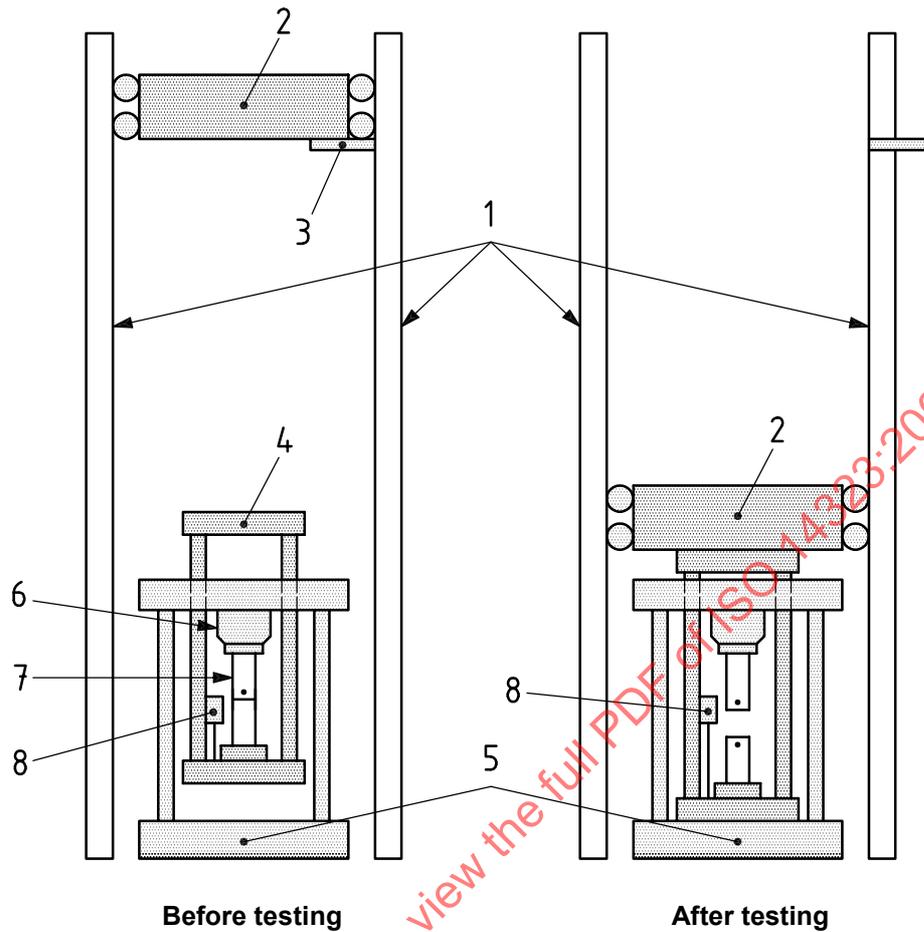
The drop-weight machine has a variable mass that can be dropped onto the specimen from different heights. There are two types of equipment as shown in Figures 7 a) and 7 b). Figure 7 a) is known as a double striking type and Figure 7 b) is known as a single striking type. The impact shear test specimen and the impact cross-tension test specimen are held in clamps as shown in Figures 8 a) and 8 b). The drop-weight machine shall be equipped with instrumentation to monitor displacement or velocity before and after impact, as well as force variation during impact. The difference in velocity can be used to calculate the total energy absorbed by the sample. To ensure complete fracture of the welded specimens, the impact energy shall be greater than 10 times the failure energy. The velocity of the drop-weight striker at the time of impact shall be in the range (5 to 15) m/s.



Key

- 1 guide columns
- 2 carriage weight
- 3 striker
- 4 inertia block
- 5 working table
- 6 specimen holder
- 7 shock absorber system
- 8 load cells

a) Double striking type

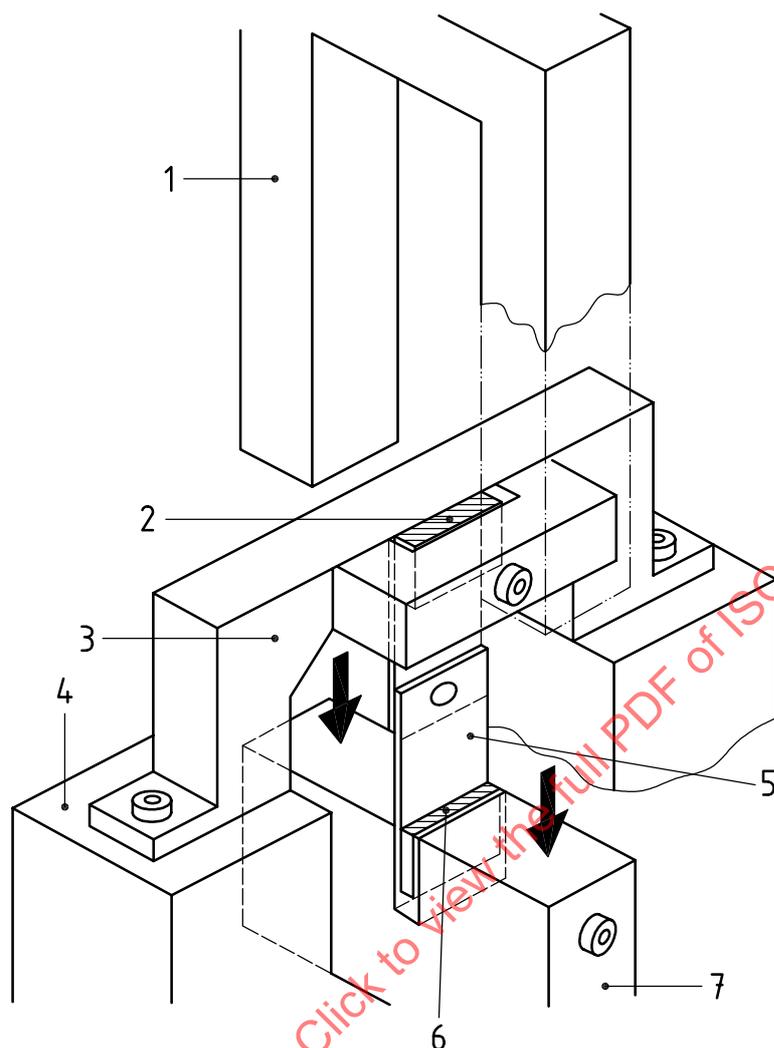


Key

- 1 guide columns
- 2 carriage weight
- 3 stopper
- 4 working frame
- 5 inertia block
- 6 load cell
- 7 test specimen
- 8 displacement sensor

b) Single striking type

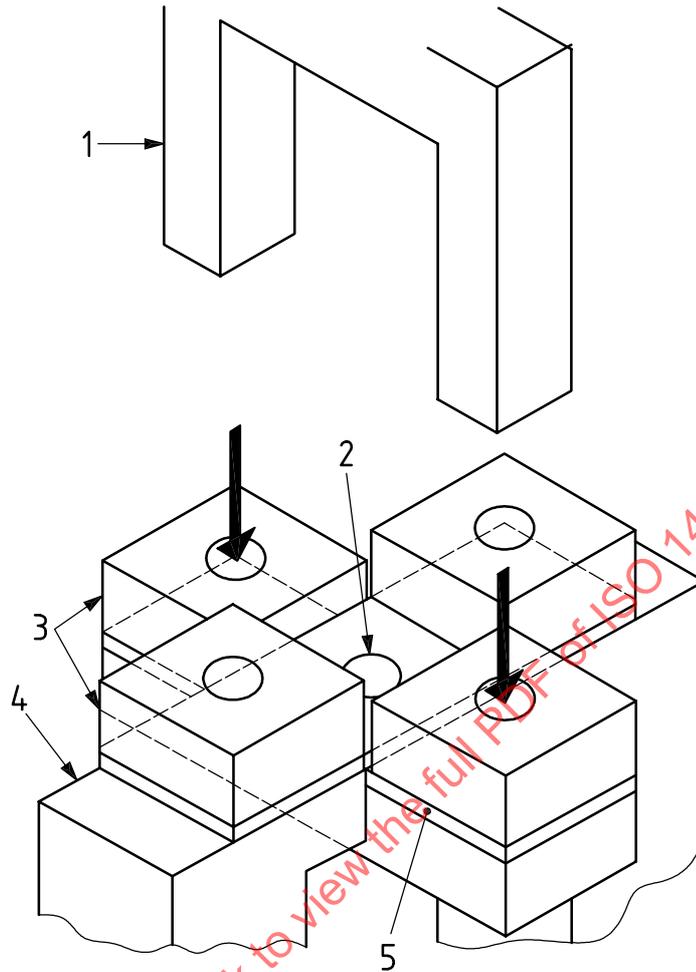
Figure 7 — Examples of drop-weight impact testing equipment



Key

- 1 striker mounted on drop-weight carriage
- 2 clamping plate
- 3 static sample holder
- 4 test jig support mounted on load measuring system
- 5 sample
- 6 clamping plate
- 7 struck sample holder

a) Shear test set-up

**Key**

- 1 striker mounted on drop-weight carriage
- 2 weld
- 3 clamping blocks
- 4 test jig support mounted on load measuring system
- 5 cross-tension test piece

b) Cross-tension test set-up

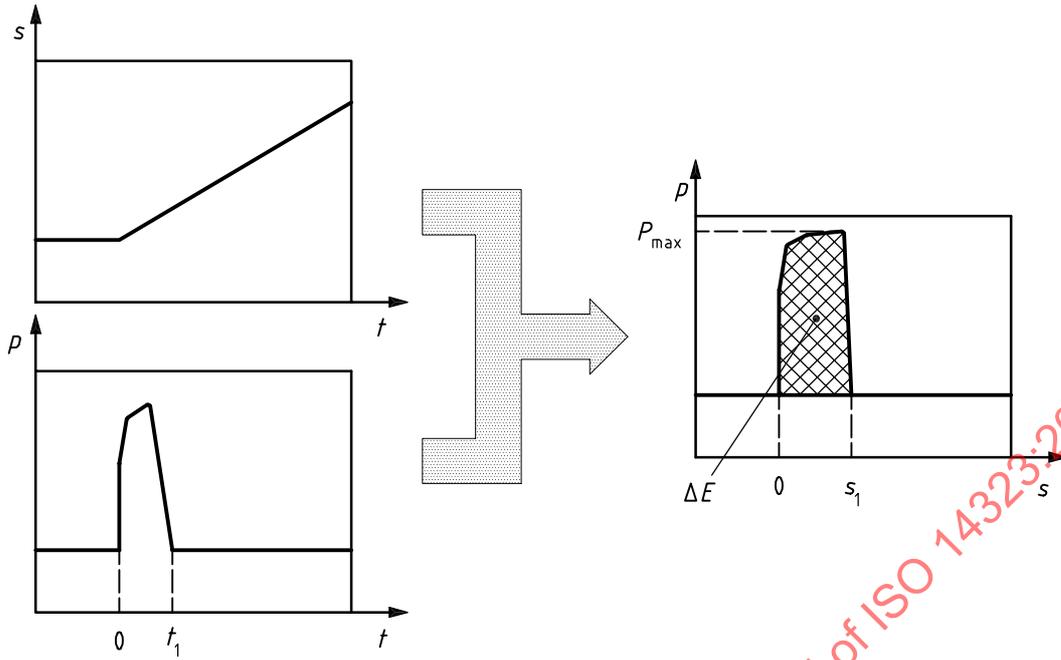
Not to scale

Figure 8 — Sketches of drop-weight impact test set-ups of double striking type

The force variation during failure shall be monitored by load cells mounted beneath the four corners of the anvil, as shown in Figure 8. Alternatively, a load cell may be mounted in the specimen clamp device to provide the force signal. Examples of results using a drop-weight machine are shown in Figure 9.

To avoid excessive attenuation of the force/time signal through the electronic filtering system, the time to fracture the specimen shall be at least 1,5 times, and ideally greater than 10 times, the response time of the filter. The optimum filtering system depends on the equipment and should be determined.

The results can be analysed by the methods contained in Annex A.



Key
 P force
 s displacement
 t time
 ΔE absorbed energy

Figure 9 — Typical traces showing displacement/time, force/time, and force/displacement

6 Test report

The test report shall include the following:

- a) a reference to the International Standard;
- b) date and place of test;
- c) testing equipment used;
- d) setting parameters of testing equipment;
- e) welding process;
- f) welding conditions and equipment;
- g) material and its condition;
- h) dimensions of the test specimens;
- i) individual values, mean value, and standard deviation of the maximum failure force and failure energy;
- j) type of fracture;
- k) individual values, mean value, and standard deviation of the weld diameter;
- l) other relevant comments;
- m) names of individuals conducting the test.

Annex A (informative)

Determination of absorbed energy

A.1 Determination of absorbed energy as a function of time for pendulum equipment

The absorbed energy is shown on the pendulum equipment dial. In addition, the force, P , may be measured using strain gauges attached to the specimen-clamping device. The absorbed energy may be derived from the area beneath the force/time curve (see Figure A.1).

A.2 Determination of absorbed energy for drop-weight equipment

A.2.1 General

In the case of the drop-weight test, the absorbed energy is calculated as a function of the displacement or time depending on the aim of the test. The absorbed energy is calculated by a single integration with no displacement measurement. The requirements for the calculations are: mass of the striker, drop height, and the force/time record.

A.2.2 Symbols and formulae

Symbol	Description	Unit
E_a	$V_0 \times$ integral of force/time	J
ΔE_0	absorbed energy	J
E_0	impact energy	J
P	impact force	N
m	mass of the striker	kg
g	acceleration due to gravity	m/s ²
V_0	impact velocity	m/s
h	drop height	m
t	time during test	s
$\int_0^{t_1} P dt$	integrated force/time	N·s

$$V_0 = \sqrt{2gh} \quad (\text{A.1})$$

$$E_a = V_0 \int_0^{t_1} P dt \quad (\text{A.2})$$

$$E_0 = \frac{mV_0^2}{2} \quad (\text{A.3})$$

$$\Delta E_0 = E_a \left(\frac{1 - E_a}{4E_0} \right) \tag{A.4}$$

EXAMPLE

m , mass of striker = 10 kg

h drop-height = 10 m

$$V_0 = \sqrt{2gh} = \sqrt{2 \times 9,81 \times 10} = 14 \text{ m/s} \tag{A.5}$$

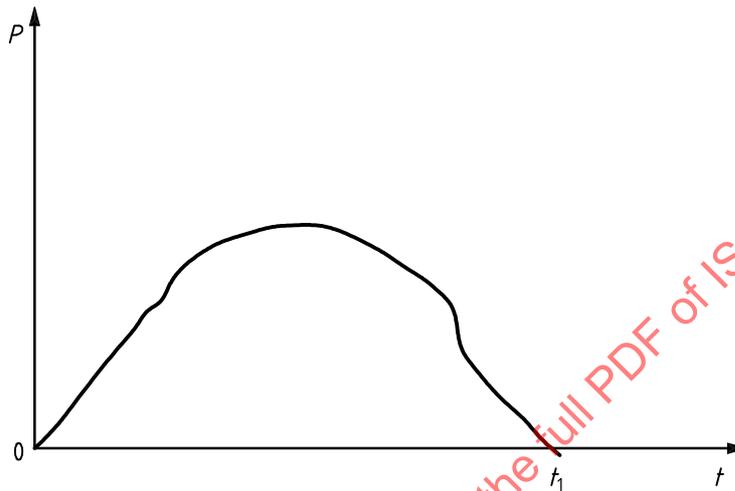


Figure A.1 — Typical impact force/time diagram

$$E_a = V_0 \int_0^{t_1} P d\tau = 14 \times 140 = 1960 \text{ J} \tag{A.6}$$

$$E_0 = \frac{1}{2} m V^2 = \frac{1}{2} \times 10 \times 14^2 = 980 \text{ J} \tag{A.7}$$

$$\Delta E_0 = E_a \left(\frac{1 - E_a}{4E_0} \right) = 1960 \left(\frac{1 - 1960}{4 \times 980} \right) = 980 \text{ J} \tag{A.8}$$

Absorbed energy = 980 J

A.3 Determination of the absorbed energy as a function of displacement for drop-weight equipment with the double-integration technique

The double-integration technique gives the force/displacement relationship from the force/time record by determination of force, acceleration and displacement. This method does not require measurement of displacement or velocity and relies solely on measurement of load (see Figure A.2).

Since the impact force, P , is equal to mass \times acceleration of the striker, a , the P/t relationship is equivalent to the a/t relationship. Therefore, double integration of P/t gives an s/t relationship (where s is displacement). Combining this with the original P/t relationship gives a P/s curve, the area under which is the equivalent to the energy absorbed.

The requirements for the calculations are impact force/time, the mass of the striker and the specimen holder, and the velocity of the striker prior to impact.