INTERNATIONAL STANDARD

ISO 7438

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Metallic materials — Bend test

Matériaux métalliques — Essai de pliage

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Contents

Page

Foreword

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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).

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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 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*.

This third edition cancels and replaces the second edition (ISO 7438:2005), which has been technically revised. The following changes have been made:

— Figure 3 has been revised;

— a note has been added in 4.2.2;

— Formula (A.4) and Figure A.1 have been revised.

Metallic materials — Bend test

1 Scope

This International Standard specifies a method for determining the ability of metallic materials to undergo plastic deformation in bending.

This International Standard applies to test pieces taken from metallic products, as specified in the relevant product standard. It is not applicable to certain materials or products, for example tubes in full section or welded joints, for which other standards exist.

2 Symbols and designations

Symbols and designations used in the bend test are shown in Figures 1 and 2 and specified in Table 1.

Table 1 — Symbols and designations

Symbol	Designation	Unit
a	Thickness or diameter of test piece (or diameter of the inscribed circle for pieces of polygonal cross-section)	mm
b	Width of the test piece	mm
L	Length of the test piece	mm
l	Distance between supports	mm
D	Diameter of the former	mm
α	Angle of bend	degrees
r	Internal radius of bend portion of test piece after bending	mm
f	Displacement of the former	mm
c	Distance between the plane including the horizontal axis of supports and the central axis of the rounded portion of the former before test	mm
p	Distance between the vertical planes including the central axis of each support and the vertical plane including the central axis of the former	mm
R	Radius of the supports	mm

3 Principle

The bend test consists of submitting a test piece of round, square, rectangular or polygonal cross-section to plastic deformation by bending, without changing the direction of loading, until a specified angle of bend is reached.

The axes of two legs of the test piece remain in a plane perpendicular to the axis of bending. In the case of a 180° bend, the two lateral surfaces may, depending on the requirements of the product standard, lie flat against each other or may be parallel at a specified distance, an insert being used to control this distance.

4 Test equipment

4.1 General

The bend test shall be carried out in testing machines or presses equipped with the following devices:

a) bending device with two supports and a former as shown in Figure 1;

b) bending device with a V-block and a former as shown in Figure 2;

c) bending device with a clamp as shown in Figure 3.

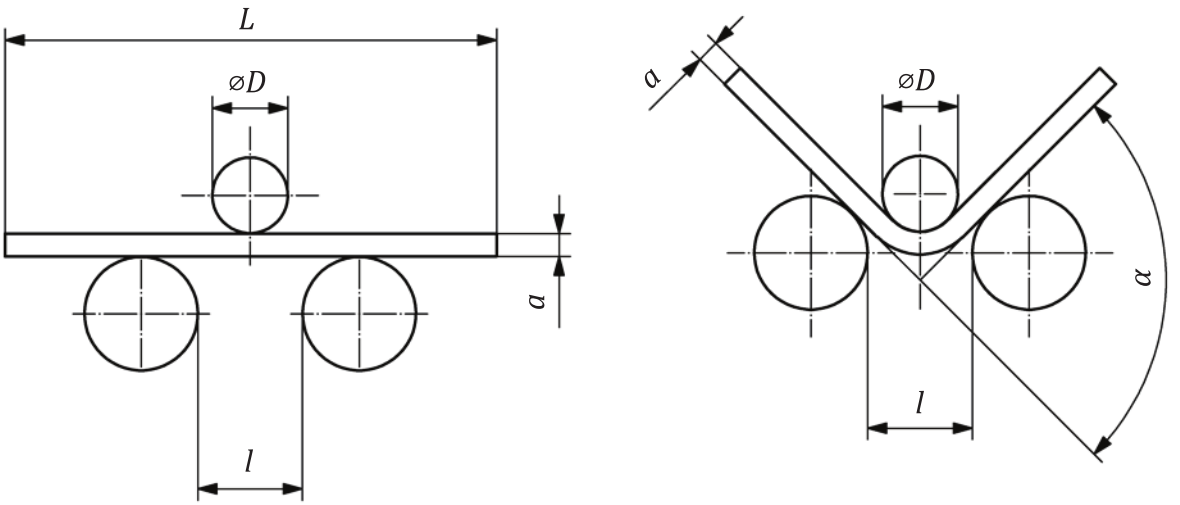


Figure 1 — Bending device with two supports and a former

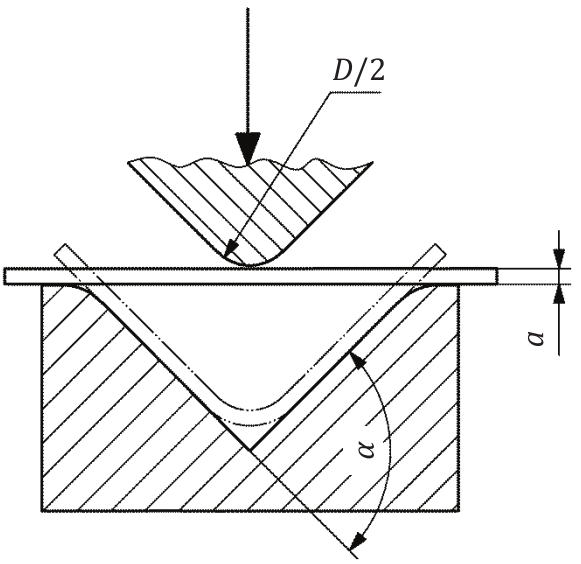
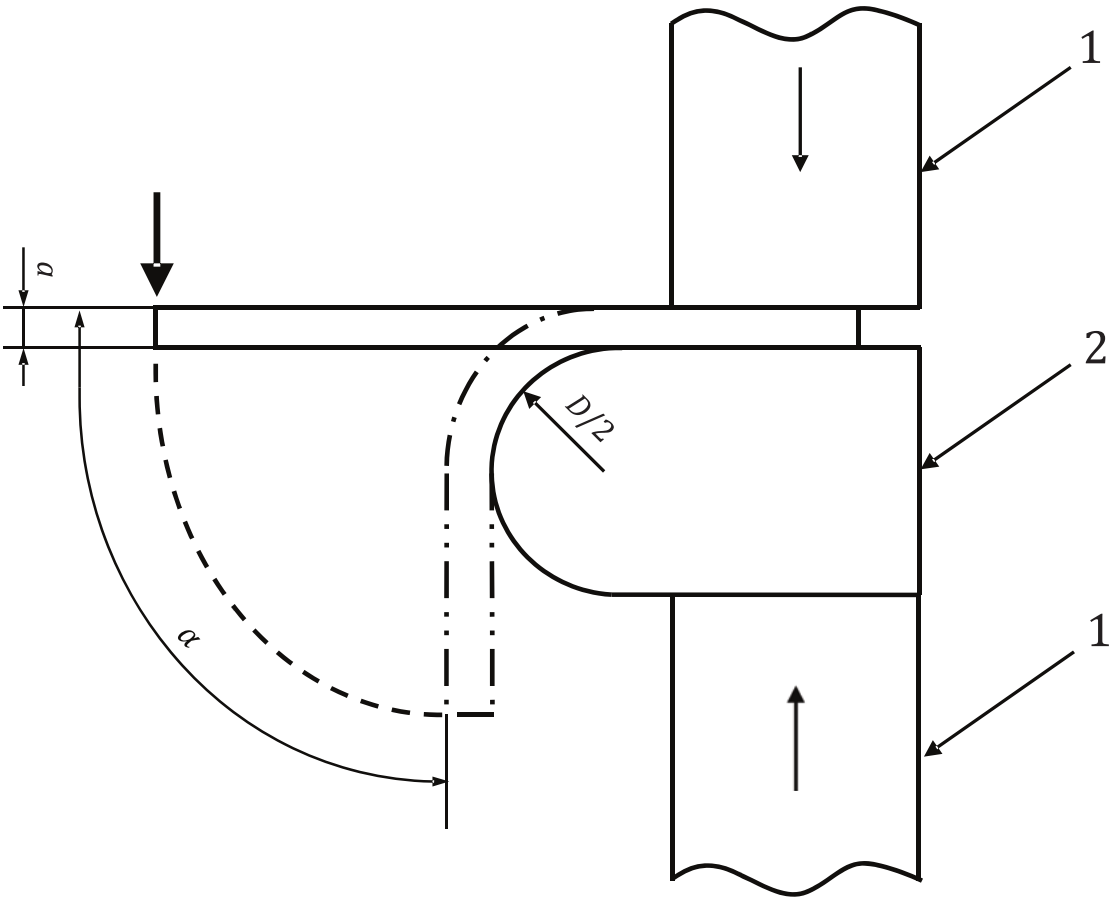


Figure 2 — Bending device with a V-block and a former



Key

1 clamp

2 former

Figure 3 — Bending device with a clamp

4.2 Bending device with supports and a former

4.2.1 The length of the supports and the width of the former shall be greater than the width or diameter of the test piece. The diameter of the former is determined by the product standard. The test piece supports and the former shall be of sufficient hardness (see Figure 1).

4.2.2 Unless otherwise specified, the distance between the supports, l, shall be:

$$l = (D + 3a) \pm \frac{a}{2} \quad (1)$$

and shall not change during the bend test.

NOTE When the distance between the supports (l) is specified smaller than or equal to D + 2a, it can result in clamping during the test and stretch forming of the test piece.

4.3 Bending device with a V-block

The tapered surfaces of the V-block shall form an angle of 180°– α (see Figure 2). The angle α is specified in the relevant standard.

The edges of the V-block shall have a radius between 1 to 10 times the thickness of the test piece and shall be of sufficient hardness.

4.4 Bending device with a clamp

The device consists of a clamp and a former of sufficient hardness; it may be equipped with a lever for applying force to the test piece (see Figure 3).

Because the position of the left face of the clamp could influence the test results, the left face of the clamp (as shown in Figure 3) should not reach up to or beyond the vertical line through the centre of the circular former shape.

5 Test piece

5.1 General

Round, square, rectangular, or polygonal cross-section test pieces shall be used in the test. Any areas of the material affected by shearing or flame cutting and similar operations during sampling of test pieces shall be removed. However, testing a test piece, the affected parts of which have not been removed, is acceptable, provided the result is satisfactory.

5.2 Edges of rectangular test pieces

The edges of rectangular test pieces shall be rounded to a radius not exceeding the following values:

— 3 mm, when the thickness of the test pieces is 50 mm or greater;

— 1,5 mm, when the thickness of the test pieces is less than 50 mm and more than or equal to 10 mm (inclusive);

— 1 mm when the thickness is less than 10 mm.

The rounding shall be made so that no transverse burrs, scratches or marks are formed which might adversely affect the test results. However, testing a test piece, the edges of which have not been rounded, is acceptable, provided that the result is satisfactory.

5.3 Width of the test piece

Unless otherwise specified in the relevant standard, the width of the test piece shall be as follows:

a) the same as the product width, if the latter is equal to or less than 20 mm;

b) when the width of a product is more than 20 mm:

   1) (20 ± 5) mm for products of thickness less than 3 mm,

   2) between 20 mm and 50 mm for products of thickness equal to or greater than 3 mm.

5.4 Thickness of the test piece

5.4.1 The thickness of test pieces from sheets, strips and sections shall be equal to the thickness of the product to be tested. If the thickness of the product is greater than 25 mm, it may be reduced by machining one surface to attain a thickness not less than 25 mm. During bending, the unmachined side shall be on the tension-side surface of the test piece.

5.4.2 Test pieces of round or polygonal cross-section shall have a cross-section equal to that of the product, if the diameter (for a round cross-section) or inscribed circle diameter (for a polygonal cross-section) does not exceed 30 mm. When the diameter, or the inscribed circle diameter, of the test piece

exceeds 30 mm up to and including 50 mm, it may be reduced to not less than 25 mm. When the diameter, or inscribed circle diameter, exceeds 50 mm it shall be reduced to not less than 25 mm (see Figure 4). During bending, the unmachined side shall be on the tension-side surface of the test piece.

Dimensions in millimetres

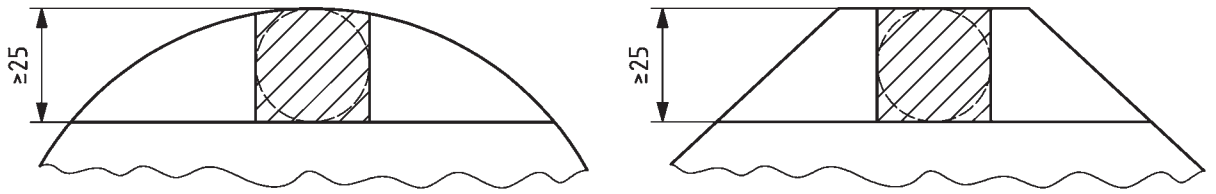


Figure 4 — Diameter and the inscribed circle diameter of the test piece

5.5 Test pieces from forgings, castings and semi-finished products

In the case of forgings, castings and semi-finished products, the dimensions of the test piece and sampling shall be as defined in the general delivery requirements, or by agreement.

5.6 Agreement for test pieces of greater thickness and width

By agreement, test pieces of a greater width and thickness than those specified in 5.3 and 5.4 may be subjected to the bend test.

5.7 Length of the test piece

The length of the test piece depends on the thickness of the test piece and the test equipment used.

6 Procedure

WARNING — During the test, adequate safety measures and guarding equipment shall be provided.

6.1 In general, tests are carried out at ambient temperature between 10 °C and 35 °C. Tests carried out under controlled conditions, where required, shall be made at a temperature of (23 ± 5) °C.

6.2 The bend test shall be carried out using one of the following methods as specified in the relevant standard:

a) a specified angle of bend is achieved under an appropriate force and for the given conditions (see Figures 1, 2 and 3);

b) the legs of the test piece are parallel to each other at a specified distance apart while under an appropriate force (see Figure 6);

c) the legs of the test piece are in direct contact while under an appropriate force (see Figure 7).

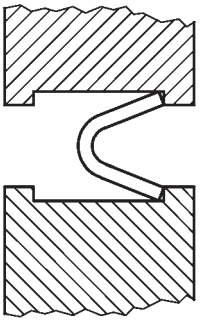


Figure 5 — Bending the legs of the test piece

Figure 6 — Legs of the test piece parallel to each other

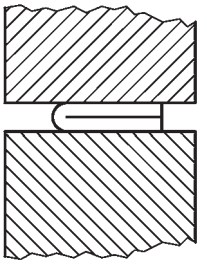


Figure 7 — Legs of the test piece in direct contact

6.3 In the bend test to a specified angle of bend, the test piece shall be placed on the supports (see Figure 1) or on the V-block (see Figure 2) and bent in the middle between supports by the action of a force. The angle of bend, α, can be calculated from the measurement of the displacement of the former as given in Annex A.

For the three methods (Figures 1, 2 and 3), the bending force shall be applied slowly so as to permit free plastic flow of the material.

In case of dispute, a testing rate of (1 ± 0,2) mm/s shall be used.

If it is not possible to bend the test piece directly to the specified angle in the manner described above, the bend shall be completed by pressing directly on the ends of the legs of the test piece (see Figure 5).

In a bend test requiring parallel legs, the test piece may be bent first, as indicated in Figure 5, and then placed between the parallel plates of the press (see Figure 6), where it is further formed by application of a force to obtain parallelism of the legs. The test may be carried out with or without an insert. The thickness of the insert shall be as defined in the relevant standard or by agreement.

An alternate method of test is that of bending over a former (see 4.4).

6.4 If specified, the test piece, after its preliminary bending, shall be further bent between the parallel plates of the press, by application of a force, to obtain direct contact between the legs of the test piece (see Figure 7).

7 Interpretation of results

7.1 The interpretation of the bend test shall be carried out according to the requirements of the product standard. When these requirements are not specified, absence of cracks visible without the use of magnifying aids is considered as evidence that the test piece withstood the bend test.

7.2 The angle of bend, specified in product standards, is always considered as a minimum. If the internal radius of a bend is specified, it is considered as a maximum.

8 Test report

The test report shall include the following information:

a) a reference to this International Standard, i.e. ISO 7438;

b) identification of the test piece (type of material, cast number, direction of the test piece axis relative to a product, etc.);

c) shape and dimensions of the test piece;

d) test method;

e) any deviation from this International Standard;

f) test result.

Annex A
(informative)

Determination of the bend angle from the measurement of the displacement of the former

This International Standard specifies the determination of the bend angle, α, of a test piece under force. The direct measurement of this angle is complicated. For this reason, the method of calculation of this angle from the measurement of the displacement, f, of the former is proposed. The bend angle, α, of the test piece under force can be determined from the displacement of the former and the values given in Figure A.1, as follows:

$$\sin\frac{\alpha}{2} = \frac{p \times c + W \times (f - c)}{p^2 + (f - c)^2} \tag{A.1}$$

$$\cos\frac{\alpha}{2} = \frac{W \times p - c \times (f - c)}{p^2 + (f - c)^2} \tag{A.2}$$

where

$$W = \sqrt{p^2 + (f - c)^2 - c^2} \tag{A.3}$$

$$c = R + a + \frac{D}{2} \tag{A.4}$$

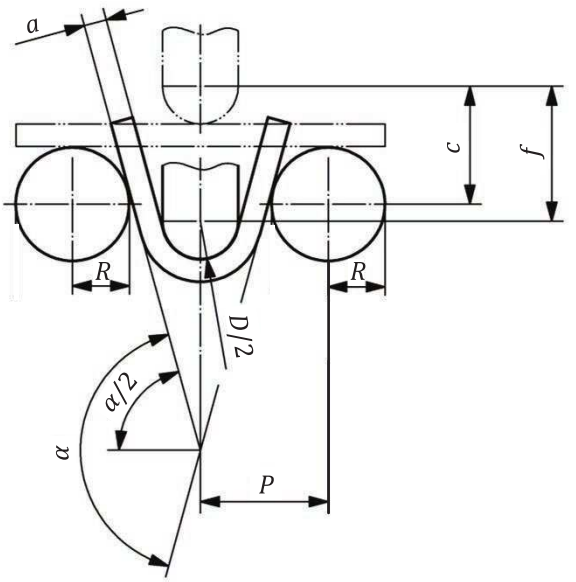


Figure A.1 — Values for the calculation of the bend angle, α

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