FINAL
DRAFT

INTERNATIONAL STANDARD

ISO/FDIS 7438

ISO/TC **164**/SC **2**

Secretariat: JISC

Voting begins on:
2020-05-12

Voting terminates on:
2020-07-07

Metallic materials — Bend test

Matériaux métalliques — Essai de pliage

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/FDIS 7438:2020(E)

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Published in Switzerland

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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).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 459, *ECISS – European Committee for Iron and Steel Standardization,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 7438:2016), which has been technically revised.

The main change compared to the previous edition is the addition of new Annex B, describing bending test at plane strain condition.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Metallic materials — Bend test

1 Scope

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

This document 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 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

4 Symbols, designations and units

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

Table 1 — Symbols, designations and units

Symbol	Designation	Unit
t	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_1	Distance between the plane including the horizontal axis of supports and the central axis of the rounded portion of the former before test	mm
D	Diameter of the former	mm
f	Displacement of the former	mm
$\bar{\theta}$	Lode angle parameter, i.e. strain path direction	—
l_{tp}	Length of the test piece	mm
l_2	Distance between supports	mm
η	Triaxiality factor	—
l_3	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_s	Radius of the supports	mm
r_i	Internal radius of bend portion of test piece after bending	mm
α	Angle of bend	degrees

5 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 can be parallel at a specified distance, an insert being used to control this distance.

6 Test equipment

6.1 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.

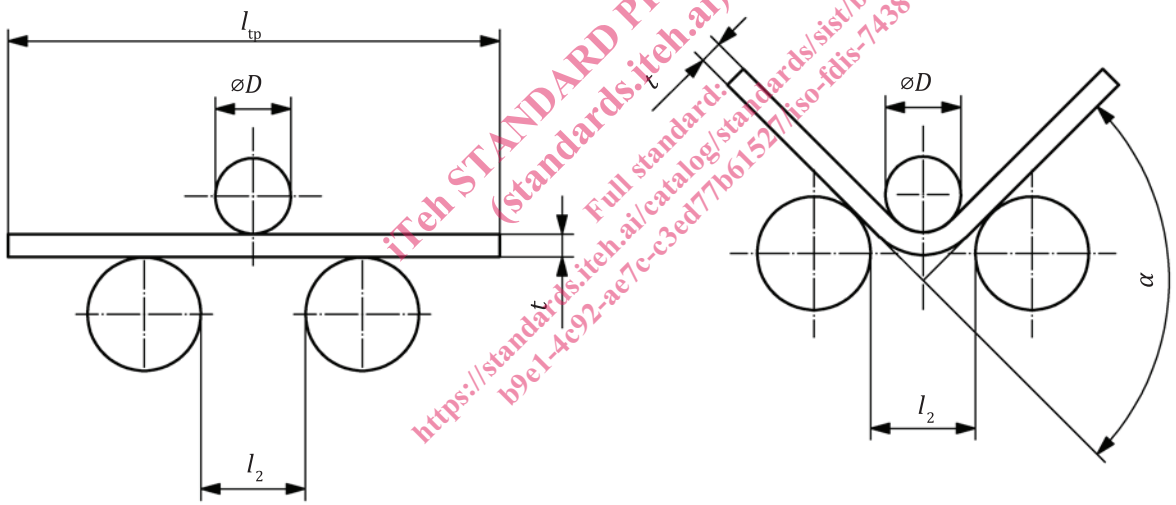


Figure 1 — Bending device with two supports and a former

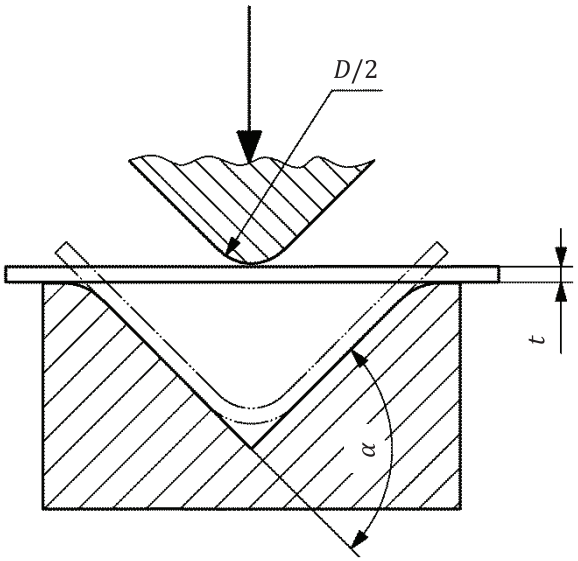
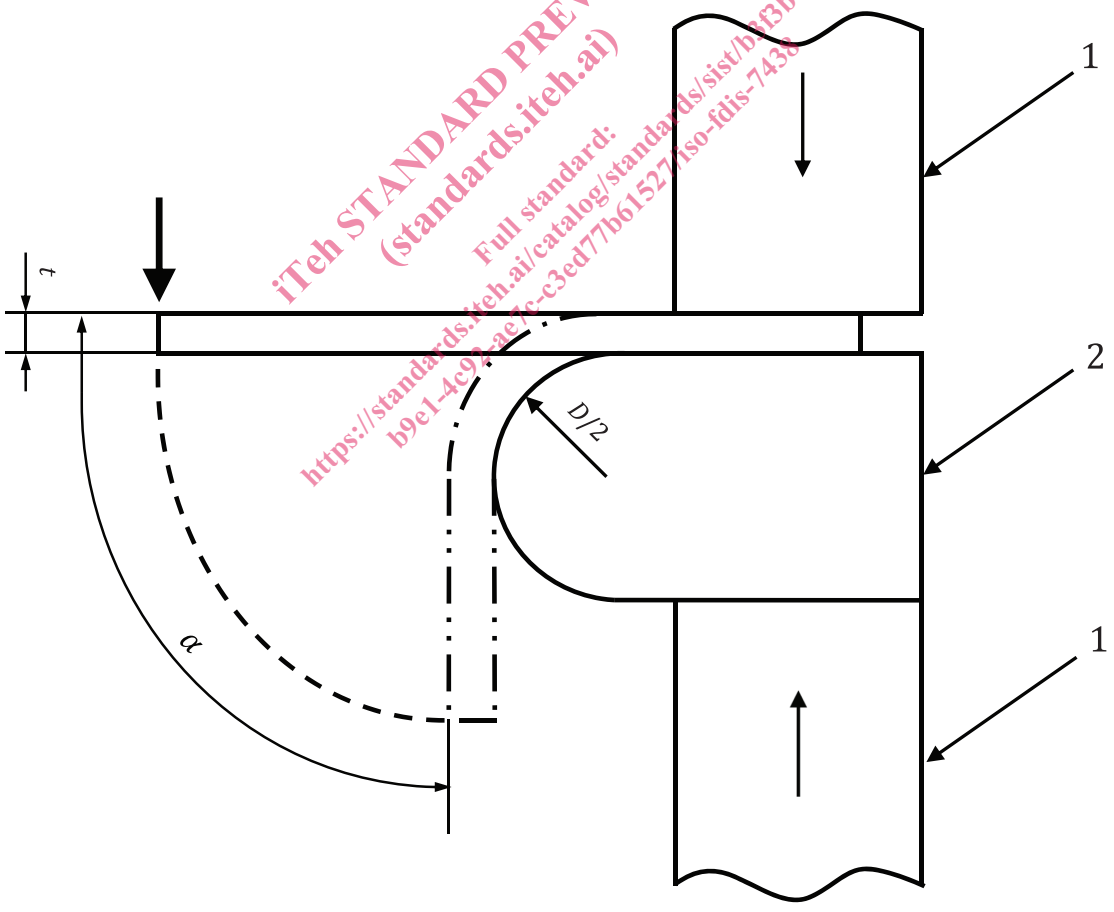


Figure 2 — Bending device with a V-block and a former



Key

1 clamp

2 former

Figure 3 — Bending device with a clamp

6.2 Bending device with supports and a former

6.2.1 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 (see Figure 1). The test piece supports and the former shall be of sufficient hardness.

6.2.2 Unless otherwise specified, the distance between the supports, l_2, shall be as given in Formula (1), and shall not change during the bend test.

$$l_2 = (D + 3t) \pm \frac{t}{2} \tag{1}$$

NOTE When the distance between the supports, l_2, is specified as smaller than or equal to $D + 2t$, it can result in clamping during the test and stretch forming of the test piece.

6.3 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 and 10 times the thickness of the test piece and shall be of sufficient hardness.

6.4 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 can 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.

7 Test piece

7.1 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 the sampling of test pieces shall be removed. However, testing a test piece, the affected parts of which have not been removed, is acceptable, provided that the result is satisfactory.

7.2 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;

— 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 can 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.

7.3 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.

If it is agreed between the parties that plane strain conditions (plane strain definition is explained in Annex B) shall be maintained for test pieces greater than 3 mm thick, then the bend test shall be carried out in accordance with Annex B.

7.4 Thickness of the test piece

7.4.1 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.

7.4.2 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

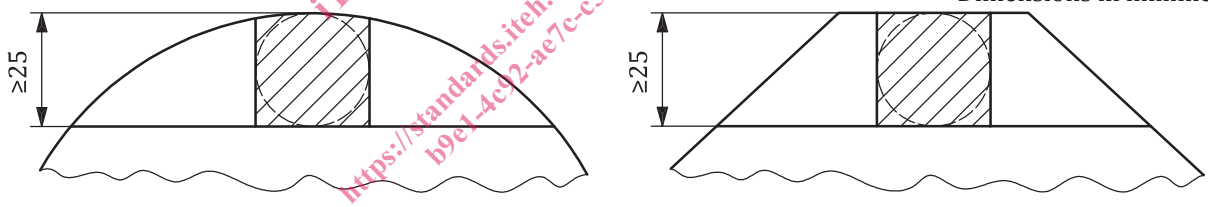


Figure 4 — Diameter and inscribed circle diameter of the test piece

7.5 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.

7.6 Agreement for test pieces of greater thickness and width

By agreement, test pieces of a greater width and thickness than those specified in 7.3 and 7.4 may be subjected to the bend test.

7.7 Length of the test piece

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