INTERNATIONAL STANDARD

ISO 5173

Second edition
2000-12-15

Destructive tests on welds in metallic materials — Bend tests

Essais destructifs des soudures sur matériaux métalliques — Essais de pliage

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Reference number
ISO 5173:2000(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.

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.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 5173 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*.

This second edition cancels and replaces the first edition (ISO 5173:1981), which has been technically revised.

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Destructive tests on welds in metallic materials — Bend tests

1 Scope

This International Standard specifies a method for making transverse root, face and side bend tests on test specimens taken from butt welds, butt welds with cladding (subdivided into welds in clad plates and clad welds) and cladding without butt welds in order to assess ductility and/or absence of imperfections on or near to the surface of the joint. It also gives the dimensions of the test specimen.

In addition this International Standard specifies a method for making longitudinal root and face bend tests to be used instead of transverse bend tests for heterogeneous assemblies when base materials and/or filler metal have a significant difference in their physical and mechanical properties in relation to bending.

This International Standard applies to metallic materials in all forms of product with welded joints made by any fusion arc welding process. Side bend tests may be carried out when the wall thickness is greater than 12 mm.

2 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

2.1
face bend test specimen for a butt weld, FBB
specimen for which the surface in tension is the side which contains the greater width of the weld or the side from which the welding arc was first applied, applicable to both transverse and longitudinal butt weld specimens

See Figures 1 and 3.

2.2
root bend test specimen for a butt weld, RBB
specimen for which the surface in tension is the side opposite to that of the face butt weld bend test specimen, applicable to both transverse and longitudinal butt weld specimens

See Figures 1 and 3.

2.3
transverse side bend test specimen for a butt weld, SBB
specimen for which the surface in tension is a cross-section of the weld

See Figure 2.

2.4
face bend test specimen for cladding without a butt weld, FBC
specimen for which the cladding is in tension, applicable to both transverse and longitudinal specimens

See Figure 4.

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2.5
side bend test specimen for cladding without a butt weld, SBC
specimen for which the cross-section of the cladding overlay is in tension, applicable to both transverse and longitudinal specimens

See Figure 5.

2.6
face or side bend test specimen for cladding with a butt weld, FBCB **or** SBCB
specimen for which the cladding is in tension or for which the cross-section of the cladding overlay is in tension and which contains a butt weld

See Figures 6 and 7.

3 Principle

Submitting a test specimen, taken transversely or longitudinally from a welded joint, to plastic deformation by bending it, without reversing the bending direction, in such a way that one of the surfaces or cross-sections of the welded joint is in tension.

Unless otherwise specified, the test shall be carried out at ambient temperature (23 ± 5) °C.

The test shall be made in accordance with one of the methods described in clause 6.

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4 Symbols and abbreviations

4.1 Symbols

See Table 1 and Figures 1 to 17.

Table 1 — Symbols and designations

Symbol	Designation	Unit
b	Width of the test specimen	mm
b_1	Width of outside fusion line	mm
d	Diameter of the former	mm
D	Outside diameter of the pipe [a]	mm
l	Distance between the rollers	mm
L_f	Initial distance between contact of the roller and the centre line of the weld	mm
L_o	Original gauge length	mm
L_s	Maximum width of the weld after machining	mm
L_t	Total length of the test specimen	mm
r	Radius of the test specimen edges	mm
R	Radius of the rollers	mm
t	Thickness of the test piece	mm
t_c	Thickness of the cladding	mm
t_s	Thickness of the test specimen	mm
t_w	Thickness of the welded joint or base material under cladding	mm
α	Bending angle	°

[a] The term "pipe", alone or in combination, is used to mean "pipe", "tube" or "hollow section (without rectangular cross section)".

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4.2 Abbreviations

FBB Face bend test specimen for a butt weld

RBB Root bend test specimen for a butt weld

SBB Transverse side bend test specimen for a butt weld

FBC Face bend test specimen for cladding without a butt weld

SBC Side bend test specimen for cladding without a butt weld

FBCB Face bend test specimen for cladding with a butt weld

SBCB Side bend test specimen for cladding with a butt weld

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4.3 Figures corresponding to the abbreviations

Figures 1 to 7 represent bend test specimens for butt welds and cladding.

The edges shall be rounded to a radius, r, on the side where the surface is in tension.

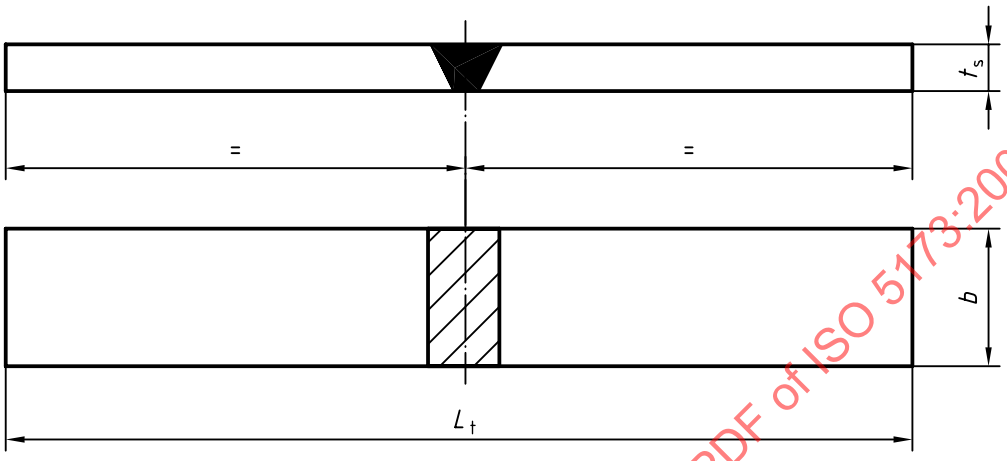

Figure 1 — Transverse root and face bend test specimen for a butt weld (RBB and FBB)

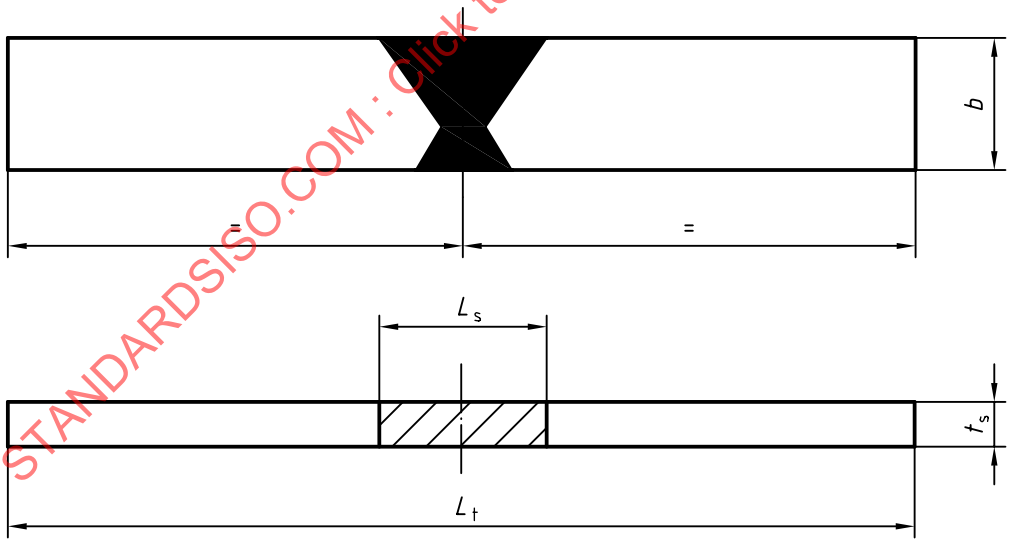

Figure 2 — Transverse side bend test specimen for a butt weld (SBB)

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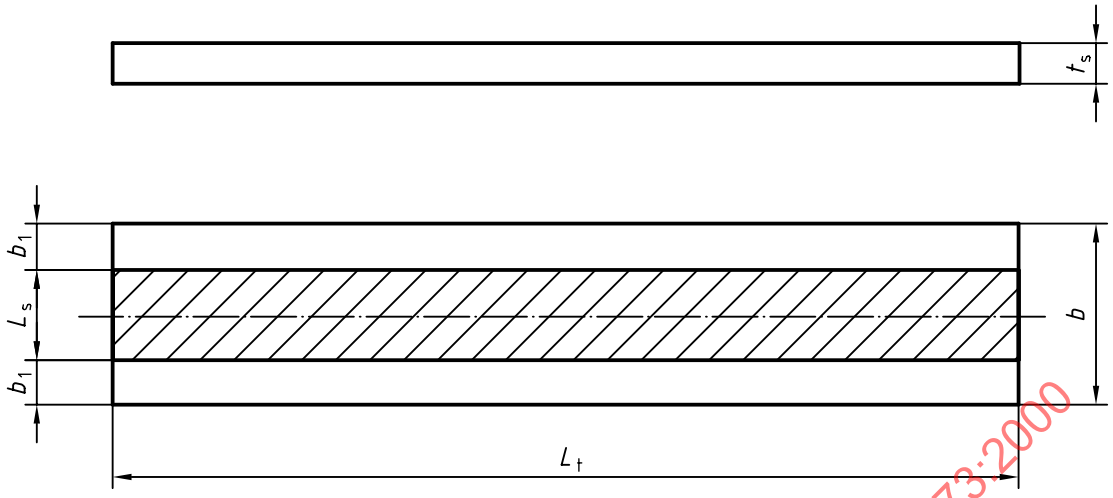

$$b_1 = \frac{b - L_s}{2}$$

Figure 3 — Longitudinal bend test specimen for a butt weld (RBB and FBB)

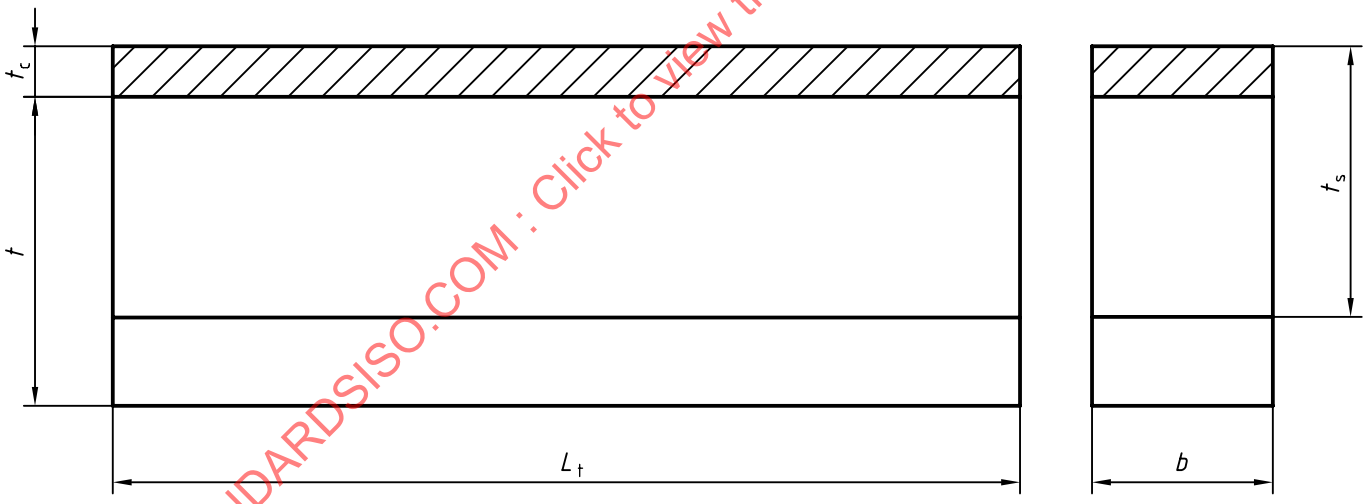

Figure 4 — Face bend test specimen for cladding without a butt weld (FBC)

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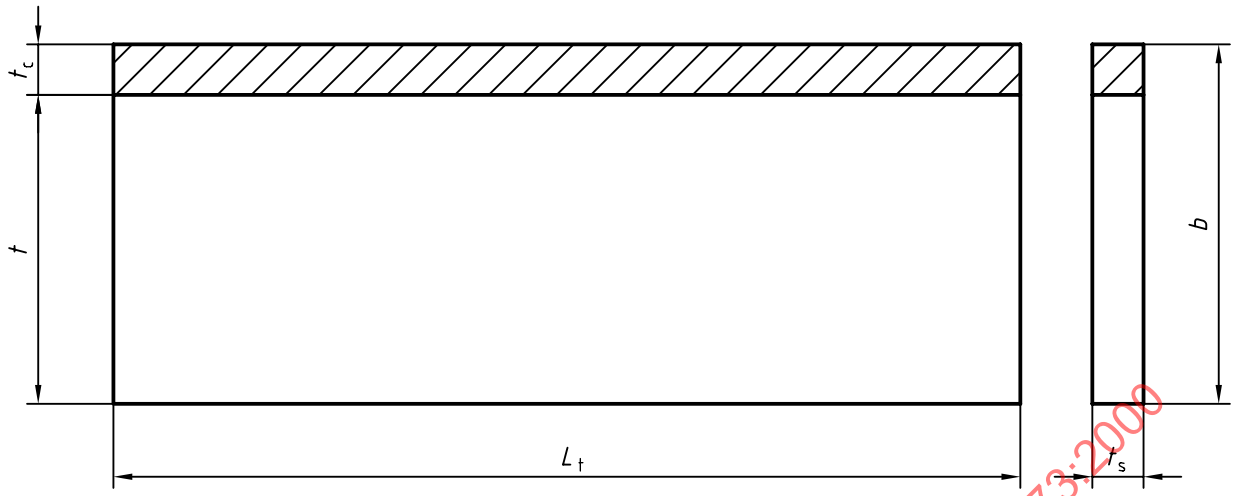

Figure 5 — Side bend test specimen for cladding without a butt weld (SBC)

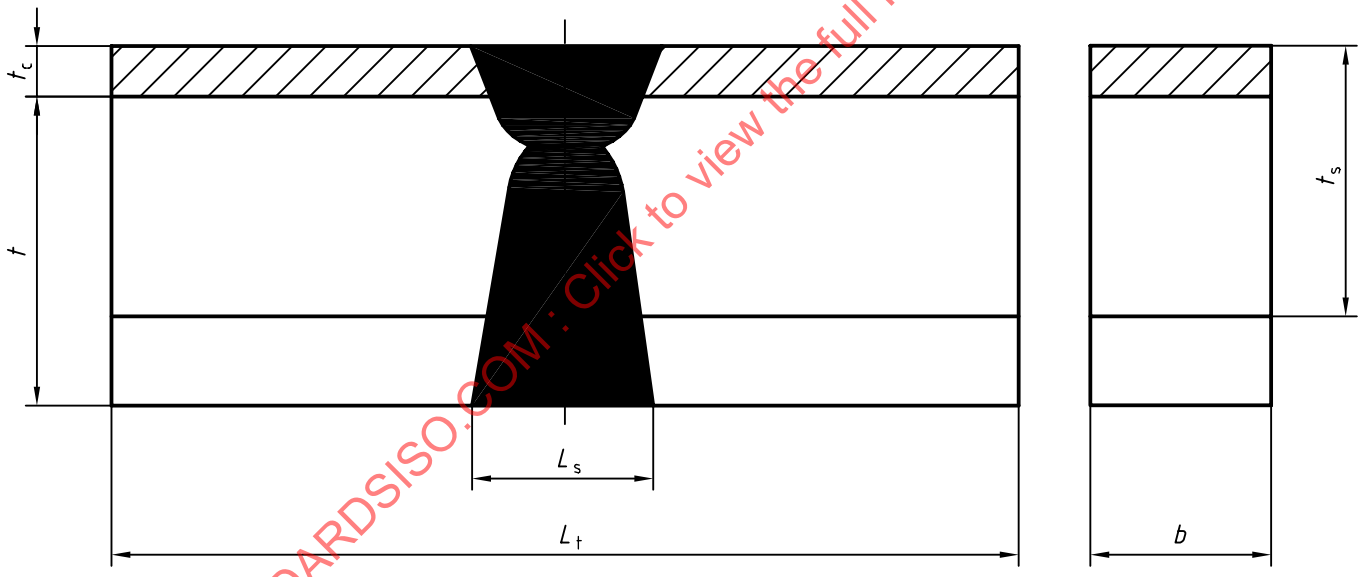

Figure 6 — Face bend test specimen for cladding with a butt weld (FBCB*)*

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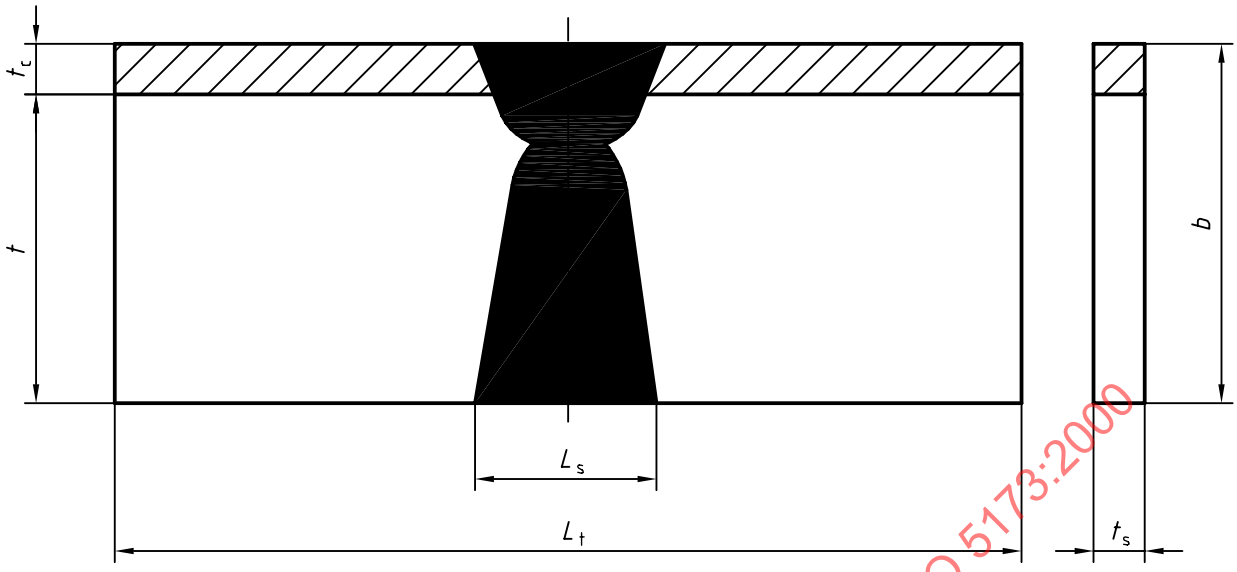

$b = t + t_c$

Figure 7 — Side bend test specimen for cladding with a butt weld (SBCB)

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5 Preparation of test specimens

5.1 General

Specimens shall be prepared in such a manner that the preparation does not affect either the base material or the weld metal.

5.2 Location

For transverse bend testing of butt welds the test specimen shall be taken transversely from the welded joint of the manufactured product or from the welded test piece in such a way that after machining the weld axis will remain in the centre of the test specimen or at a suitable position for testing.

For longitudinal bend testing of butt welds the test specimen shall be taken longitudinally from the welded joint of the manufactured product or from the welded test piece.

The location and orientation of bend test specimens of cladding shall be specified by the application standard or by agreement between the contracting parties.

5.3 Marking

Each test piece shall be marked to identify its exact location in the manufactured product or in the joint from which it has been removed.

If required by the relevant application standard, the direction of working (e.g. rolling or extrusion) shall be marked.

Each test specimen shall be marked to identify its exact location in the test piece from which it has been removed.

When removed from the test piece, each test specimen shall be marked.

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5.4 Heat treatment and/or ageing

No heat treatment shall be applied to the welded joint or to the test specimen unless it is specified or permitted by the relevant application standard dealing with the welded joint to be tested. Details of any heat treatment shall be recorded in the test report. If natural ageing of aluminium alloys takes place, the time between welding and testing shall be recorded.

5.5 Extraction

5.5.1 General

The mechanical or thermal processes used to extract the test specimen shall not change the properties of the test specimen in any way.

5.5.2 Steel

Shearing shall not be used for thicknesses > 8 mm. If thermal cutting or other cutting methods which could affect the cut surfaces are used to extract the test specimen from the welded plate, or from the test piece, the cuts shall be made at a distance $\geqslant$ 8 mm from the test specimen but in any case sufficient (depending on the process used) not to introduce metallurgical effects which could affect the test results.

5.5.3 Other metallic materials

Shearing and thermal cutting are not permitted; only machining (e.g. sawing or milling) shall be used.

5.6 Size of specimens

5.6.1 Transverse root and face bend tests of a butt weld (RBB and FBB)

See Figure 8.

For transverse root and face bend tests the test specimen thickness, t_s, shall be equal to the thickness of the base material adjacent to the welded joint.

When a relevant application standard requires testing of a full thickness > 30 mm, several test specimens may be taken in order to cover the full thickness of the joint.

In such cases, the location of the test specimen in the welded joint thickness shall be identified.

5.6.2 Transverse side bend tests of a butt weld (SBB)

See Figure 9.

For side bend tests the test specimen width, b, shall be equal to the thickness of the base material of the welded joint. The specimen shall have a thickness, t_s, of at least $(10 \pm 0{,}5)$ mm and, in addition, shall be such that $b \geqslant 1{,}5\ t_s$.

The ratio between the thickness, t_s, and the diameter of the former, d, shall conform to the requirements of the relevant application standard.

When the joint thickness exceeds 40 mm, it is permissible to take several specimens from the welded joint, instead of one only, provided the width, b, of each test specimen is in the range from 20 mm to 40 mm. In these cases the location of the test specimen in the welded joint thickness shall be identified.

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5.6.3 Longitudinal bend tests of a butt weld (RBB and FBB)

See Figure 10.

For longitudinal bend tests the test specimen thickness, t_S, shall be equal to the thickness of the base material near the welded joint. If the test piece thickness, t, is greater than 12 mm, the test specimen thickness, t_S, shall be equal to (12 ± 0,5) mm and the face or root of the weld shall be in tension.

5.6.4 Face bend tests of cladding without a butt weld (FBC)

See Figure 11.

For face bend tests the test specimen thickness, t_S, shall be equal to the thickness of the base material plus the thickness of the cladding up to a maximum of 30 mm.

When the thickness of the base material plus cladding exceeds 30 mm, it is permissible to remove material from the base material in order to produce a test specimen thickness, t_S, in accordance with the application standard or as agreed between the contracting parties.

5.6.5 Side bend tests of cladding without a butt weld (SBC)

See Figure 12.

For side bend tests the test specimen width, b, shall be equal to the thickness of the base material plus the thickness of the cladding up to a maximum of 30 mm. The specimen shall have a thickness, t_S, of at least (10 ± 0,5) mm and, in addition, shall be such that $b \geqslant 1{,}5\ t_S$.

When the thickness of the base material plus cladding exceeds 30 mm, it is permissible to remove material from the base material to produce a test specimen width, b, in accordance with the application standard or as agreed between the contracting parties.

5.6.6 Transverse face bend tests of cladding with a butt weld (FBCB)

See Figure 13.

For transverse face bend tests of cladding with a butt weld the test specimen thickness, t_S, shall be equal to the thickness of the base material plus the thickness of the cladding.

In such a case, the location of the weld shall remain in the middle of the test specimen or at a suitable position for testing.

When the test concerns the complete joint incorporating both the butt joint and the cladding and when the thickness of the joint exceeds 30 mm, several specimens may be taken as described in 5.6.1 and Figure 1.

When the purpose of the test is to examine the cladding only and when the thickness of the specimen, t_S, exceeds 30 mm, no further tests on the base material are required.

Figures 8 to 13 represent the location of bend test specimens for butt welds and cladding.

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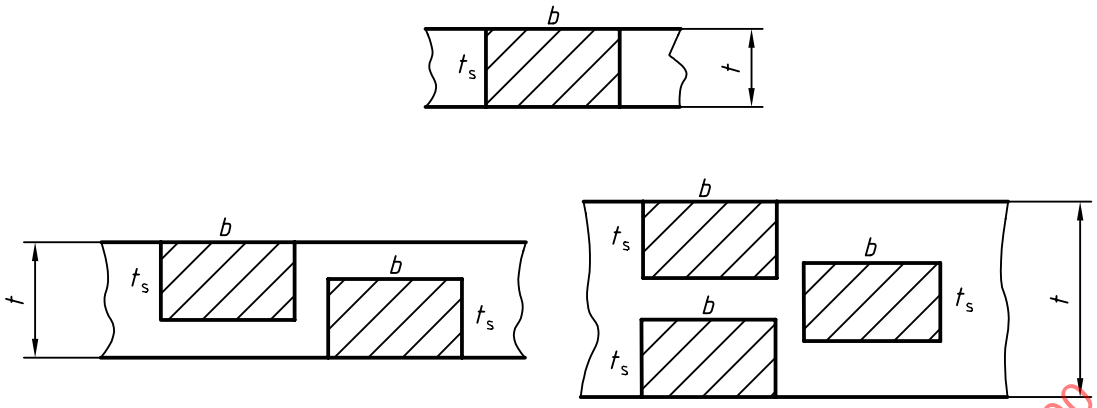


Figure 8 — Root and face bend test specimens for a butt weld (RBB and FBB)

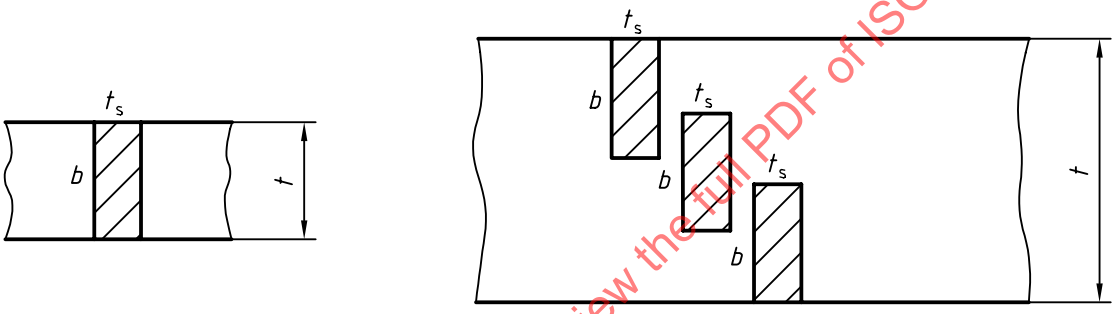
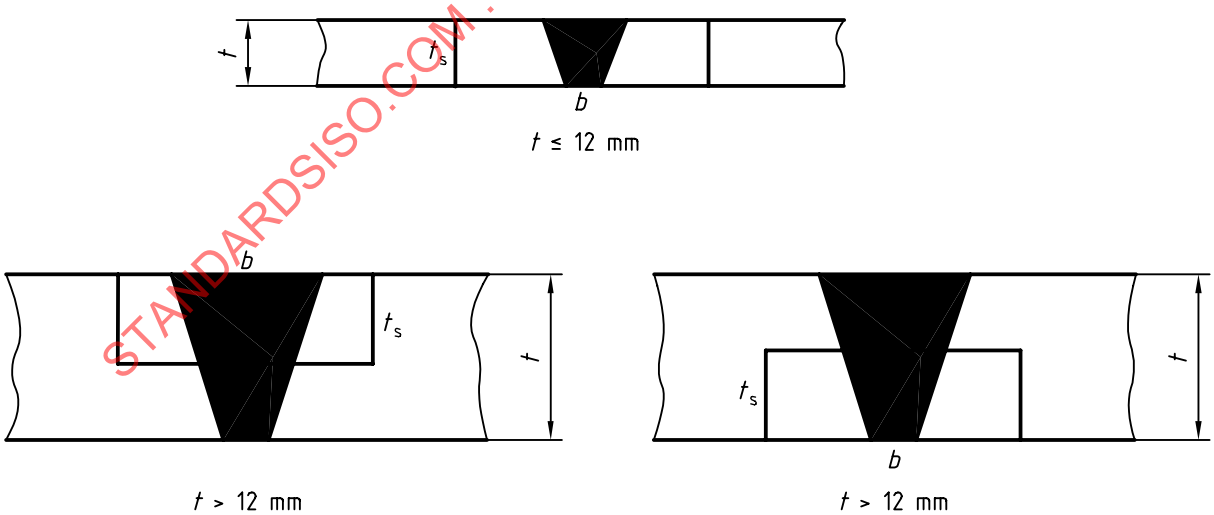


Figure 9 — Side bend test specimens for a butt weld (SBB)



Position of the test specimen if the face is in tension

Position of the test specimen if the root is in tension

Figure 10 — Longitudinal bend test specimens for a butt weld (RBB and FBB)

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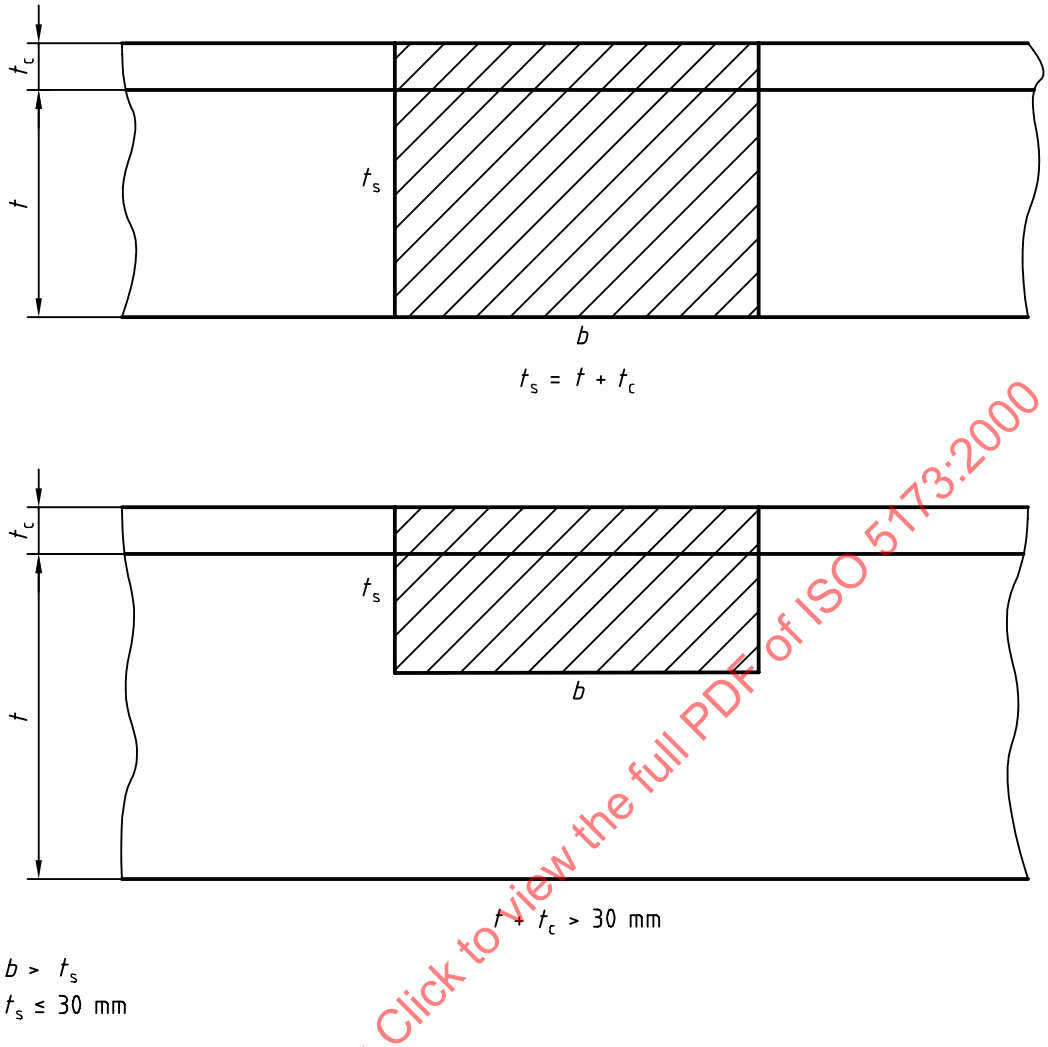

Figure 11 — Face bend test specimens for cladding without a butt weld (FBC)

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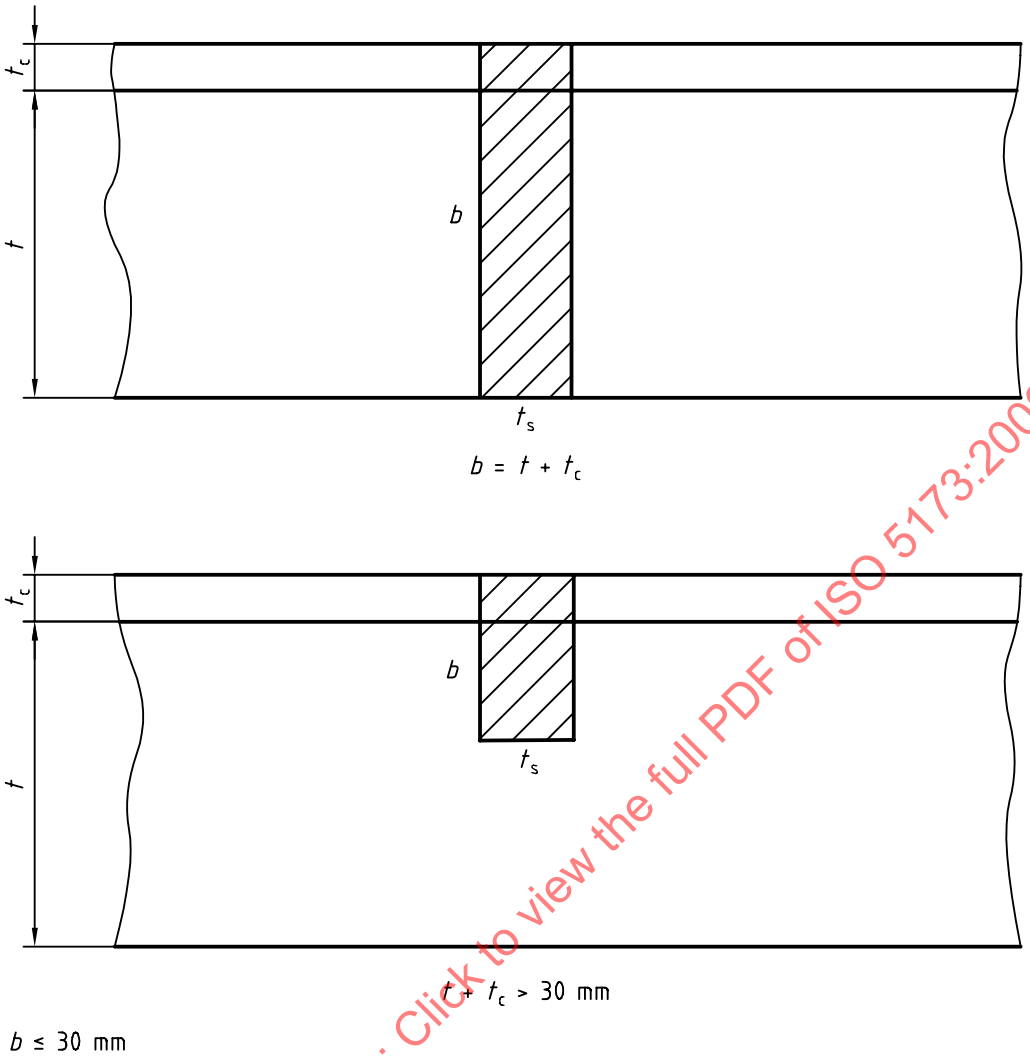

Figure 12 — Side bend test specimens for cladding without a butt weld (SBC)

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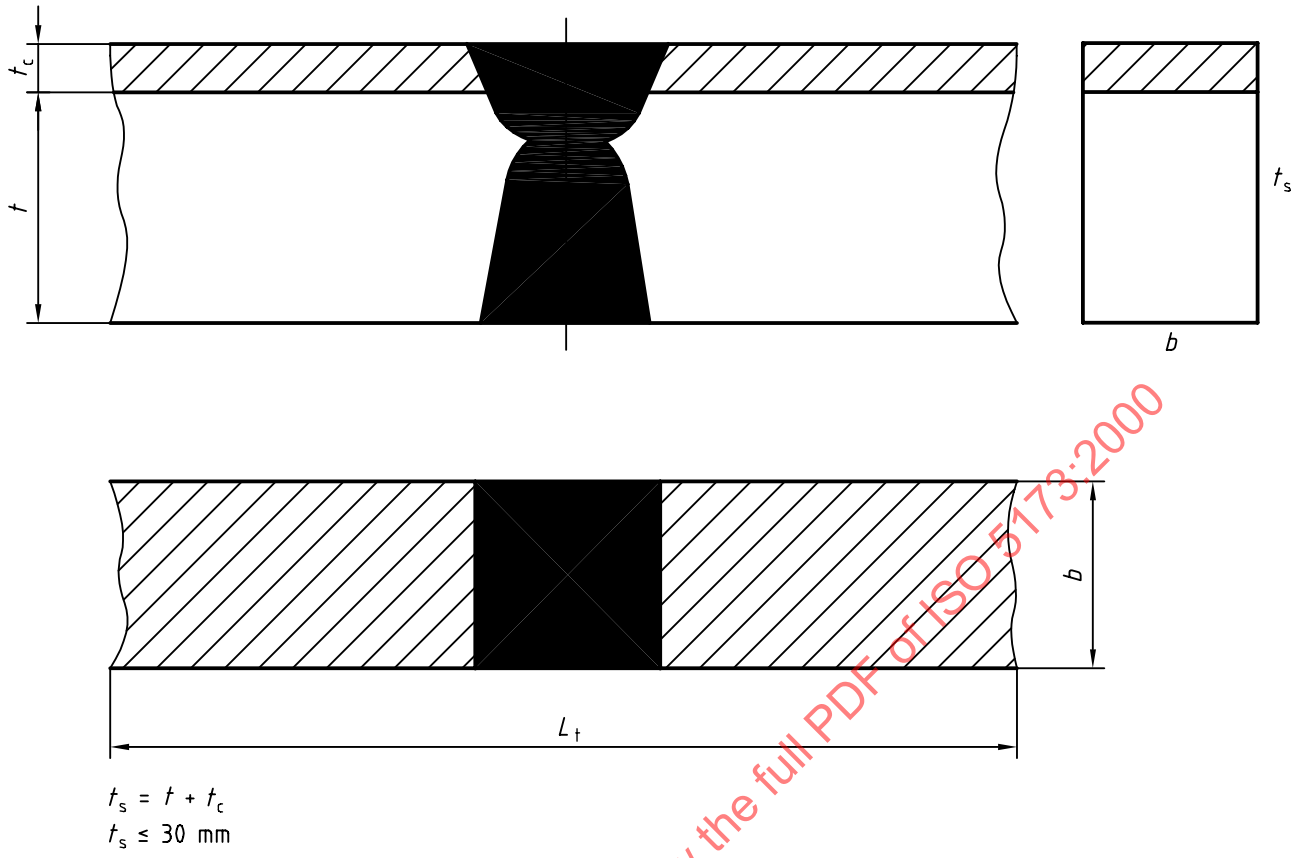

NOTE If $t + t_c > 30$ mm, see Figure 8.

Figure 13 — Transverse bend test specimens for cladding with a butt weld (FBCB)

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5.6.7 Dimensions

5.6.7.1 Length

The length L_t of test specimens shall be $L_t \geqslant l + 2R$ and at least be such that the requirements of the appropriate application standards are fulfilled.

5.6.7.2 Thickness

For the thickness, t_s, see 5.6.1 to 5.6.6.

5.6.7.3 Width

a) Transverse root or face bend tests

1) For plates

— for steel, the width b of the test specimen shall not be less than $1{,}5 \times t_s$, with a minimum of 20 mm;

— for aluminium, copper and their alloys, the width b of the test specimen should be not less than $2t_s$, with a minimum of 20 mm.

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2) For pipes, the width b of the test specimen shall be a minimum of:

— for pipe diameters $\leqslant$ 50 mm: $t + 0{,}1\ D$ (with a minimum of 8 mm);

— for pipe diameters $>$ 50 mm: $t + 0{,}05\ D$ (with a minimum of 8 mm and a maximum of 40 mm).

NOTE For an outside diameter, D, $> 25 \times$ the wall thickness of the pipe, the specimen may be taken as required for the flat plates.

b) Transverse side bend tests:

The width b of the test specimen shall generally be equal to the thickness of the base material near the welded joint.

c) Longitudinal bend tests:

The width b of the test specimen shall be:

$$b = L_s + 2b_1$$

Table 2 — Width of longitudinal bend specimen

Dimensions in millimetres

Material	t_s	b (see Figure 3)
Steel	$\leqslant 20$	$L_s + 2 \times 10$
	> 20	$L_s + 2 \times 15$
Aluminium, copper and their alloys	$\leqslant 20$	$L_s + 2 \times 15$
	> 20	$L_s + 2 \times 25$
NOTE The width of the specimen for other metallic materials is by agreement between the contracting parties.		

5.6.7.4 Edges

The edges of the test specimen on the face in tension shall be rounded by mechanical means to a radius r not exceeding $0{,}2t_s$ to a maximum of 3 mm (see Figure 14).

5.6.8 Surface preparation

The final stages of preparation shall be obtained by machining or grinding, suitable precautions being taken to avoid superficial strain hardening or excessive heating of the material. Within the length l (see Figures 14 to 16), the surface shall be free from scratches or notches transverse to the test specimen direction except for undercut which shall not be removed unless required by the relevant application standard and/or by agreement between the contracting parties.

The surfaces of the test specimen shall be machined in such a way that, unless otherwise specified in the relevant application standard and/or by agreement between the contracting parties, all excess weld metal is removed. Unless otherwise specified, the penetration bead may be left intact inside pipes of small diameter on the opposite side of the former.

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6 Conditions of testing

6.1 Etching

Before starting the bend test, the shape and the position of the fusion zone or fusion line may be established by lightly macroetching the surface of the test specimen to be tested in tension.

6.2 Testing

6.2.1 Testing with a former

See Figures 14 to 16.

The test shall be carried out by placing the test specimen on two supports consisting of parallel rollers. The weld shall be at the mid-point between the rollers, except for longitudinal bend tests. The test specimen shall be bent by loading gradually and continuously in the middle of the span, on the axis of the weld, with a load applied by a former (three-point bending) perpendicularly to the test specimen surface.

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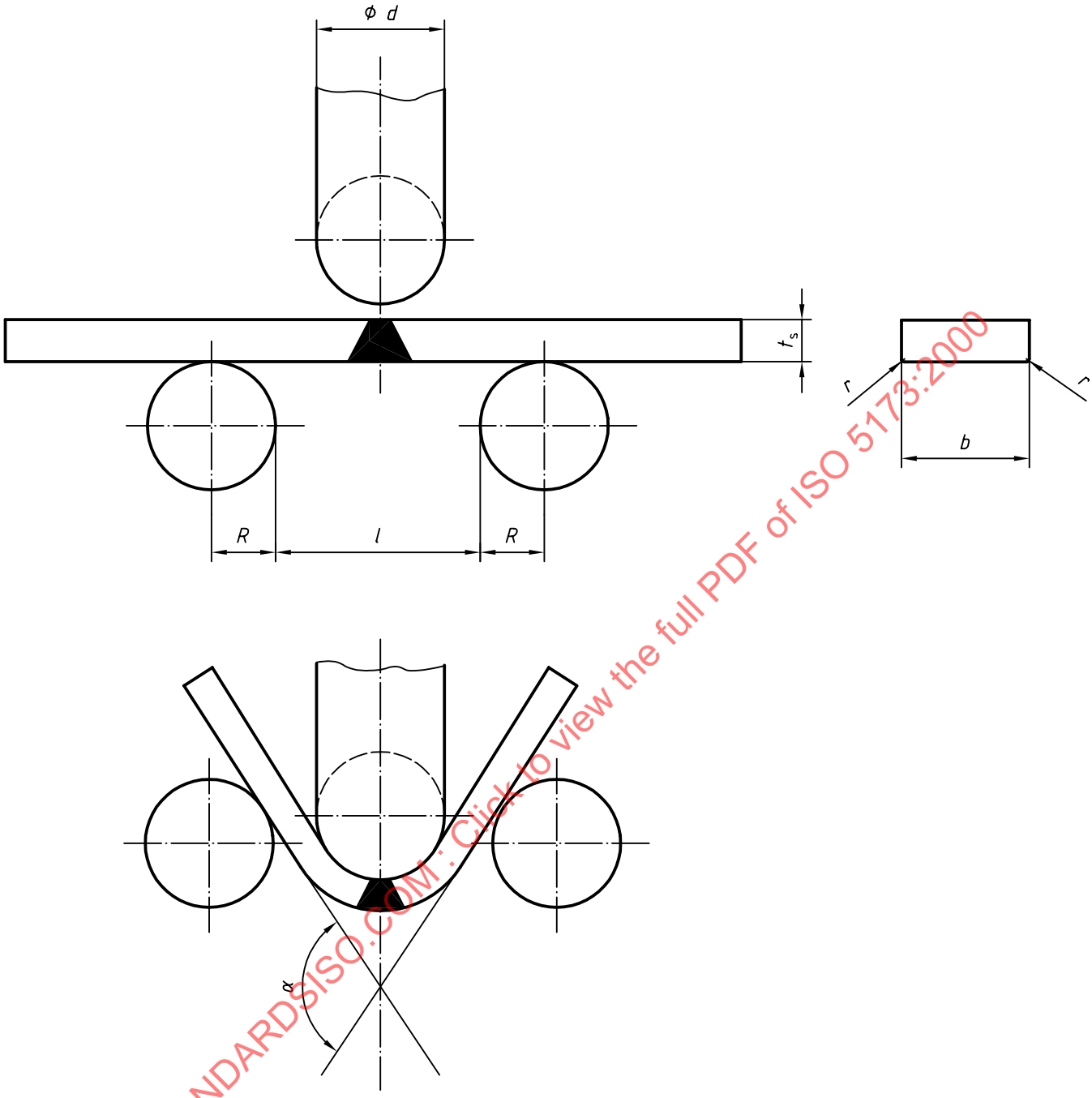

$d + 2t_s < l \leqslant d + 3t_s$

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Figure 14 — Transverse face or root bend test

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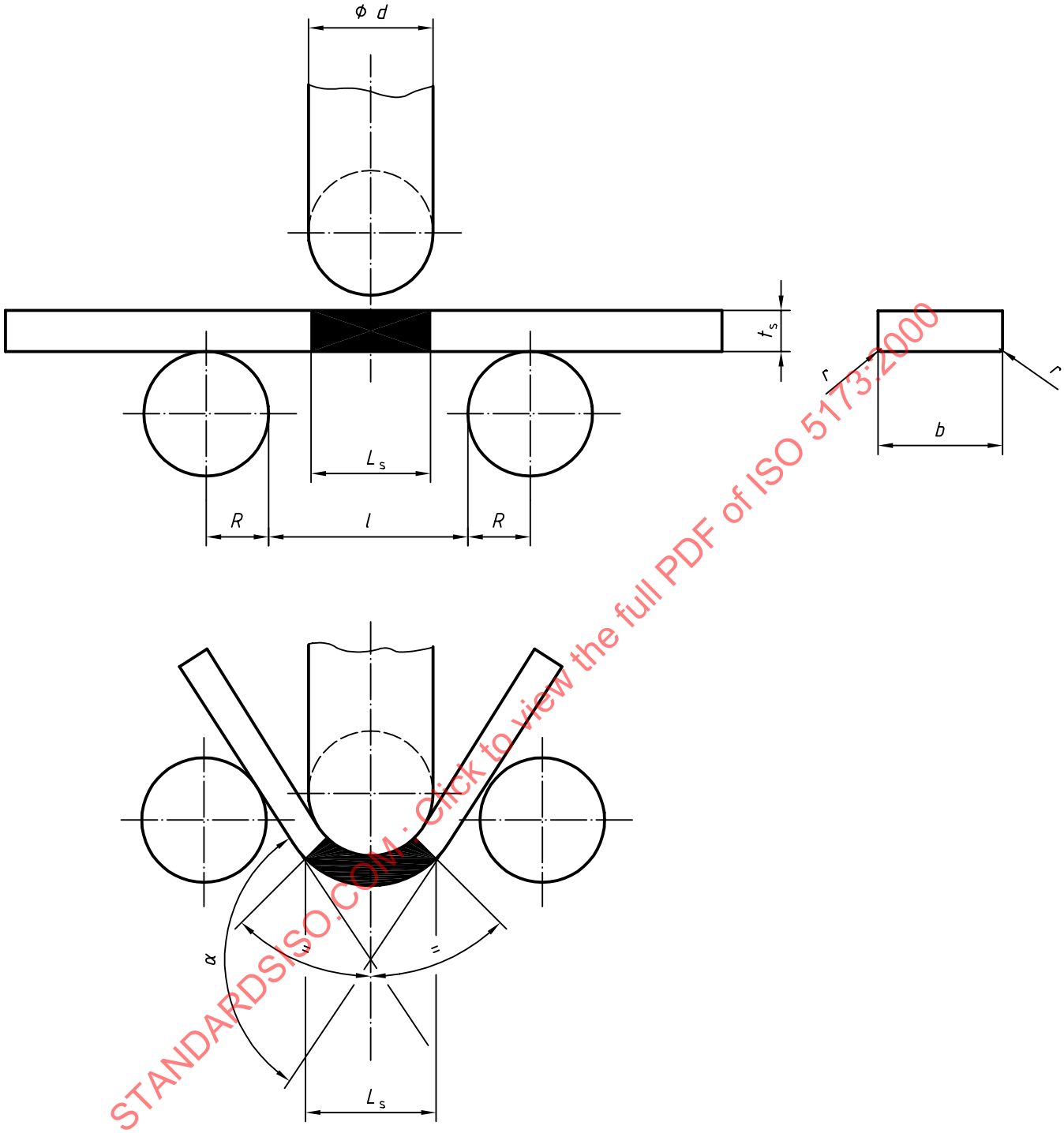

$d + 2t_s < l \leqslant d + 3t_s$

$d \geqslant 1{,}3L_s - t_s$

Figure 15 — Transverse side bend test

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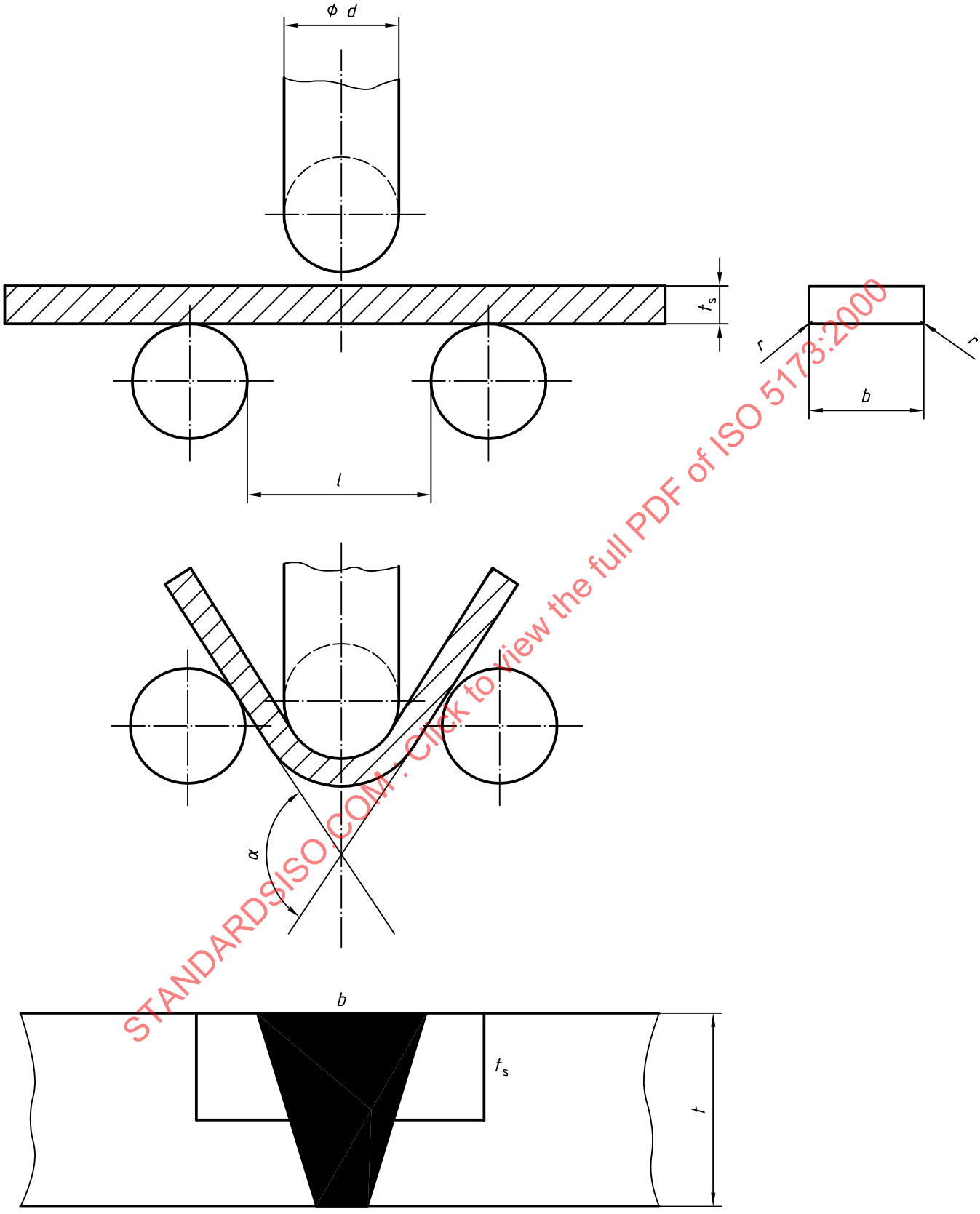

$d + 2t_s < l \leqslant d + 3t_s$

Figure 16 — Longitudinal bend test

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