
Destructive tests on welds in metallic materials — Fracture test

*Essais destructifs des soudures sur matériaux métalliques — Essai
de texture*



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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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document 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 9017:2001), which has been revised to update the normative references.

Request for official interpretations of any aspect of this document should be directed to the Secretariat of ISO/TC 44/SC 5 via your national standards body. A complete listing of these bodies can be found at www.iso.org.

Destructive tests on welds in metallic materials — Fracture test

1 Scope

This document specifies the sizes of test specimen and the procedures for carrying out fracture tests in order to obtain information about types, sizes and distribution of internal imperfections such as porosities, cracks, lack of fusion, lack of penetration and solid inclusions on the fracture surface.

This document applies to metallic materials in all forms of product with joints made by any fusion welding process with a thickness greater or equal to 2 mm.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 10042, *Welding — Arc-welded joints in aluminium and its alloys — Quality levels for imperfections*

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1 examination length

L_f

length of the test specimen measured along the weld axis between any side notches

Note 1 to entry: See [Figure 6](#).

3.2 total examination length

ΣL_f

sum of the lengths of all the test specimens comprising the test piece, measured along the weld axis, of the fracture faces between the side notches of the test specimens

Note 1 to entry: See [Figure 6](#).

3.3 examination thickness

a_f
thickness of the fracture area for each test specimen

Note 1 to entry: See [Figures 7](#) and [8](#).

3.4 examination area

A_f
product of the examination length and the examination thickness for each test specimen

3.5 total examination area

ΣA_f
sum of all examination areas

4 Principle

Fracture the joint through the weld metal in order to examine the fracture surface. The fracture can be induced by bending or tension, static or dynamic loading. Furthermore, notch dimensions and temperature can be varied to induce the fracture.

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

5 Symbols and abbreviated terms

The symbols and abbreviated terms to be used for fracture tests are specified in [Table 1](#) and represented in [Figures 5](#) to [8](#).

Normally, it is sufficient to give the basic denomination, but for special applications, additional denominations about the notching and test method can be requested.

EXAMPLE 1 Test specimen taken from a fillet weld with an examination length of 40 mm and examination thickness of 10 mm.

Without any requirement about notching and test method:

Basic denomination: FW / ($L_f a_f$)

i.e. for this example: FW / (40×10)

With additional requirement (square face notching and test method):

Comprehensive denomination: FW / ($L_f a_f$) / Fq (See [Figure 8](#).)

i.e. for this example: FW / (40×10) / Fq (See [Figure 8](#).)

EXAMPLE 2 Test specimen taken from a butt weld with an examination length of 40 mm and examination thickness of 10 mm.

Without any requirement about notching and test method:

Basic denomination: BW / ($L_f a_f$)

i.e. for this example: BW / (40×10)

With additional requirement (round side notching and test method):

Comprehensive denomination: BW / ($L_f a_f$) / Sr (See [Figure 6](#).)

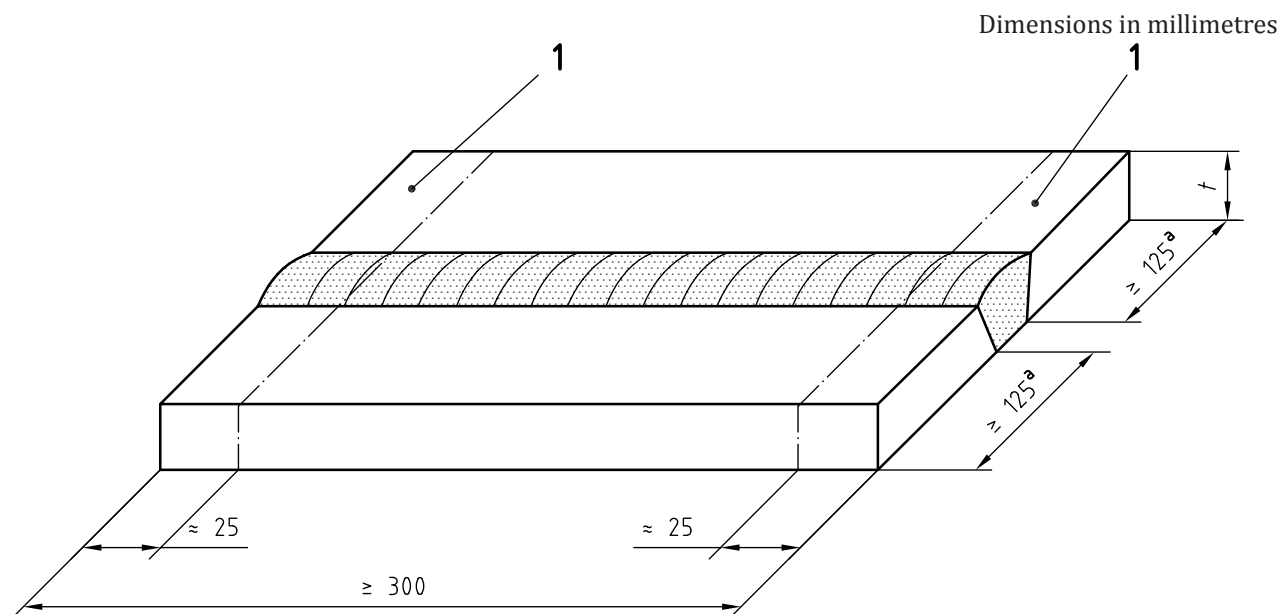
i.e. for this example: BW / (40×10) / Sr (See [Figure 6](#).)

Table 1 — Symbols and abbreviated terms

Denomination	Symbol or abbreviated term	Unit
Butt weld	BW	—
Fillet weld	FW	—
Thickness of test piece	t, t_1, t_2	mm
Length of test piece	l_1, l_2	mm
Outside diameter of tube	D	mm
Test specimen and test piece		
— examination length	L_f	mm
— examination thickness	a_f	mm
— examination area	A_f	mm ²
— area of imperfections	A_i	mm ²
Side notch	S	—
— square (q)	Sq	—
— round (r)	Sr	—
— sharp (s)	Ss	—
Longitudinal notch		
Face notch	F	—
— square (q)	Fq	—
— round (r)	Fr	—
— sharp (s)	Fs	—
Root notch	R	—
— square (q)	Rq	—
— round (r)	Rr	—
— sharp (s)	Rs	—

6 Dimensions of test pieces

Unless otherwise specified by the application standard or by agreement between the contracting parties, test piece dimensions shall be in accordance with [Figures 1](#) to [4](#). The test piece shall provide sufficient test specimens for the required total examination length (ΣL_f) and area (ΣA_f).

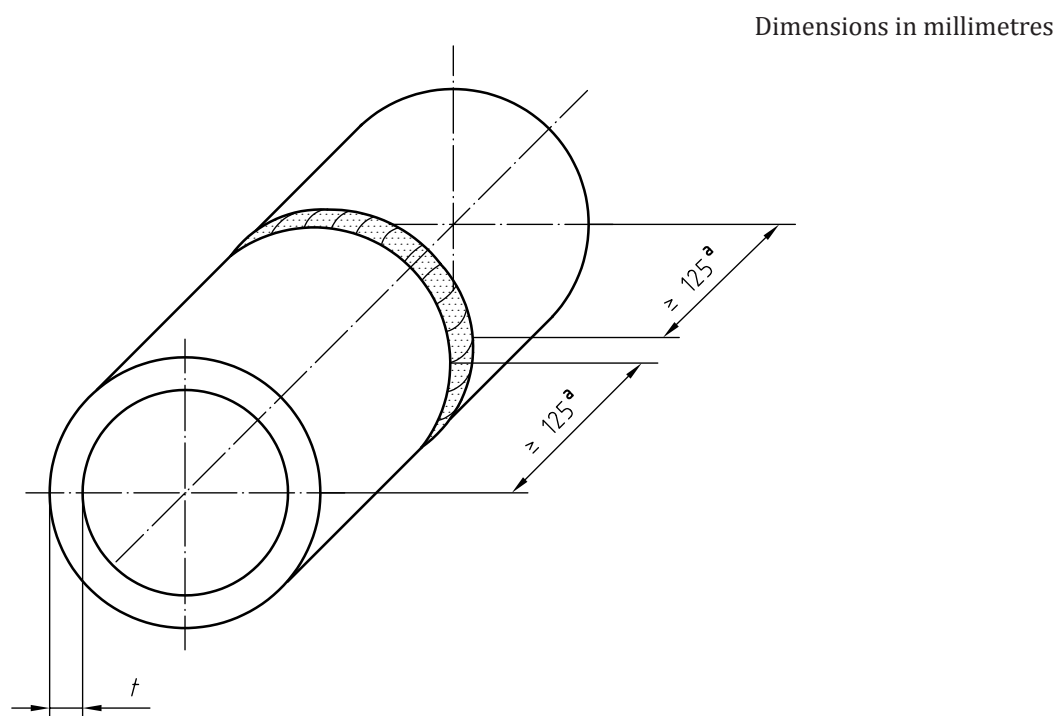


Key

1 discard

^a ≥ 150 mm for materials of high thermal conductivity (e.g. aluminium and copper).

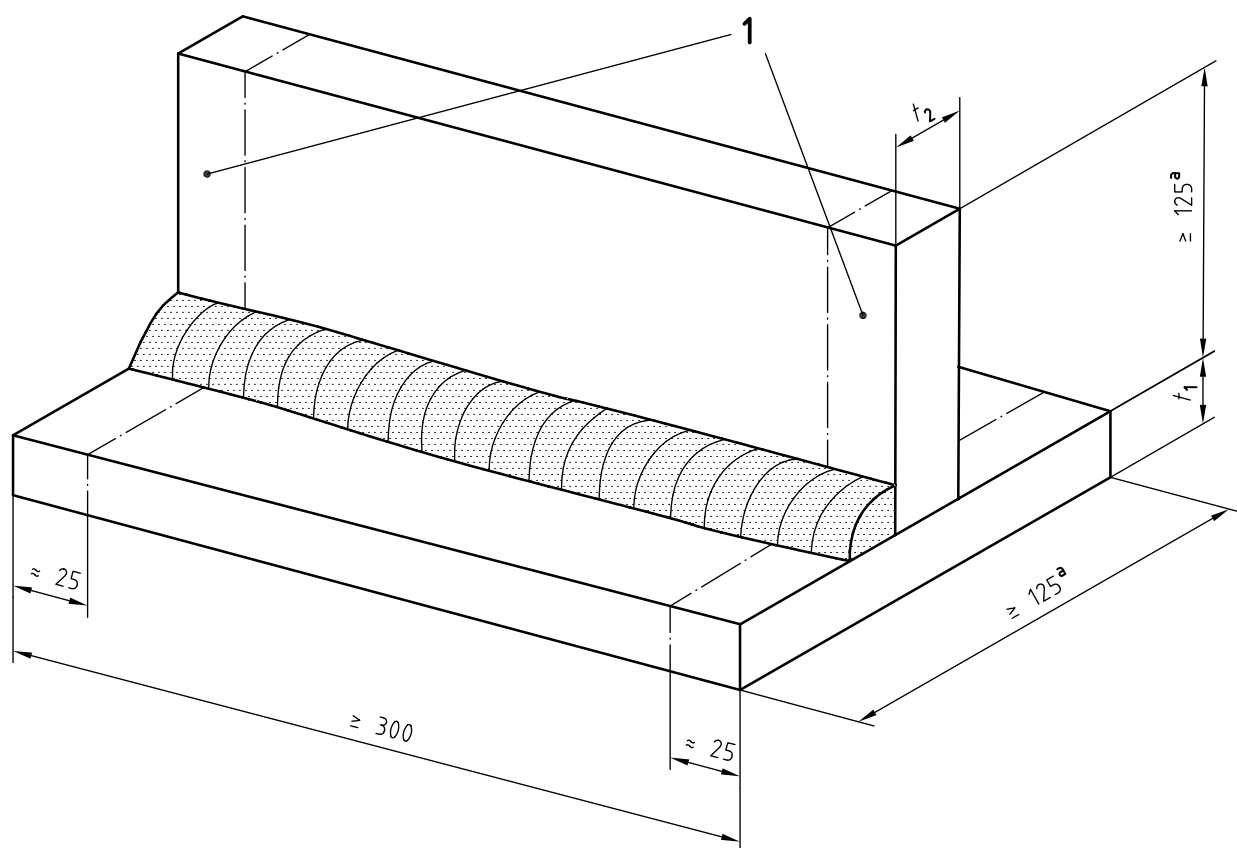
Figure 1 — Test piece for butt welds in plate



Key

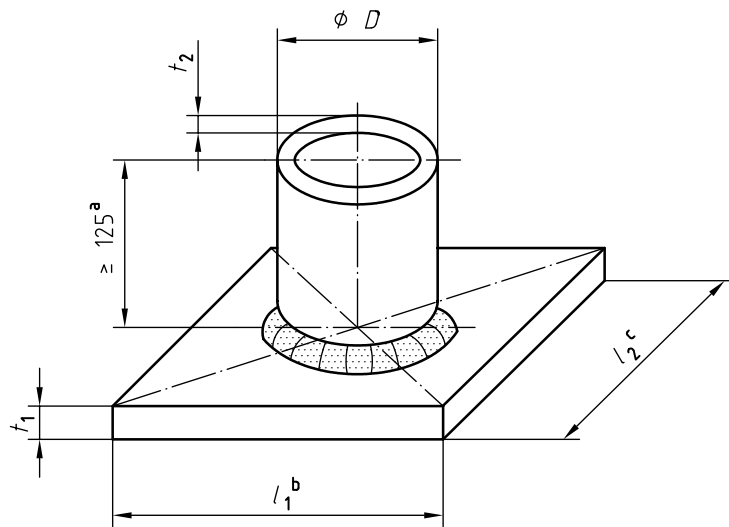
^a ≥ 150 mm for materials of high thermal conductivity (e.g. aluminium and copper).

Figure 2 — Test piece for butt welds in pipe

**Key**

1 discard

a ≥ 150 mm for materials of high thermal conductivity (e.g. aluminium and copper).**Figure 3 — Test piece for fillet welds on plate**

**Key**

- a ≥ 150 mm for materials of high thermal conductivity (e.g. aluminium and copper).
- b $l_1 \approx l_2$; $l_1 \geq (D + 100)$.
- c $l_2 \geq (D + 100)$.

Figure 4 — Test piece for fillet welds on pipe**7 Removal of test specimens****7.1 General**

The examination length, L_f , and area, A_f , and the number of test specimens shall be specified by the application standard or by agreement between the contracting parties. Welded joints in plates shall be cut transversely to the welded joint in test specimens of approximately equal weld length. The weld axis shall remain in the middle of the test specimen for butt welds.

For welded joints in pipe, unless otherwise specified in the application standard or by agreement between the contracting parties, the test piece shall provide at least two test specimens.

When carrying out bend tests, equal numbers of specimens shall be tested with the root in tension and the face in tension. If the pipe diameter is too small for removing the required number of test specimens, additional test pieces shall be welded.

7.2 Marking

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

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

7.3 Extraction**7.3.1 General**

The extraction method shall avoid the introduction of detrimental thermal or mechanical effects.

In general, a portion 25 mm from both ends of the test welds shall be discarded, unless information about the ends of the welds is required (e.g. start/stop imperfections).

7.3.2 Steels

The test specimens shall be cut by thermal cutting or by mechanical means.

7.3.3 Other metallic materials

Other metallic materials shall only be cut mechanically.

7.4 Preparation

Fracture of welds in plates or pipes may be assisted by one or more of the following:

- removing the weld reinforcement;
- notching both edges of the weld (side notching);
- notching into the reinforcement (longitudinal notching).

Depending on the ductility of the weld metal, square, round or sharp notches may be used, (see [Figures 5, 6, 7 and 8](#)). For materials of high ductility (e.g. aluminium and copper), sharp notches can be recommended.

The depth of the notches shall be sufficient to induce fracture in the weld.

Unless otherwise specified by the application standard or by agreement between the contracting parties, the notch depth should be such that:

- for the side notch, examination length, L_f , shall be greater than or equal to 70 % of the original width of the test specimen, w (see [Figure 6](#)), or the total examination length, ΣL_f , shall be greater than or equal to 60 % of the length of the test specimen;
- for the longitudinal notch, examination thickness, a_f , shall be greater than or equal to 80 % of the original thickness of the test specimen, t (see [Figure 7](#)).

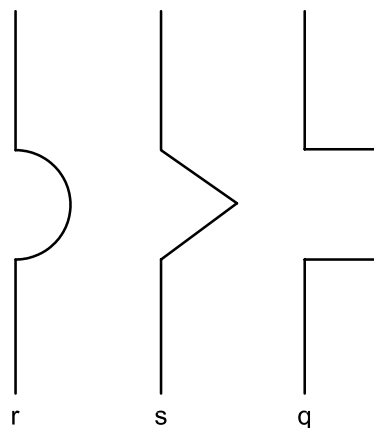
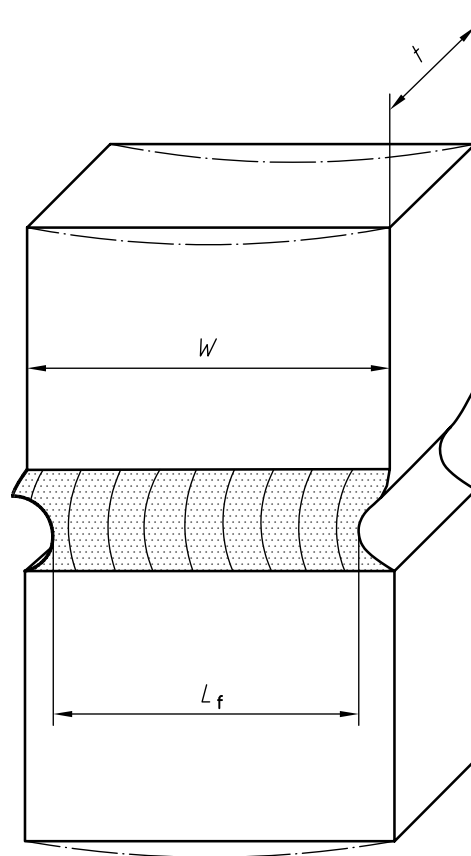
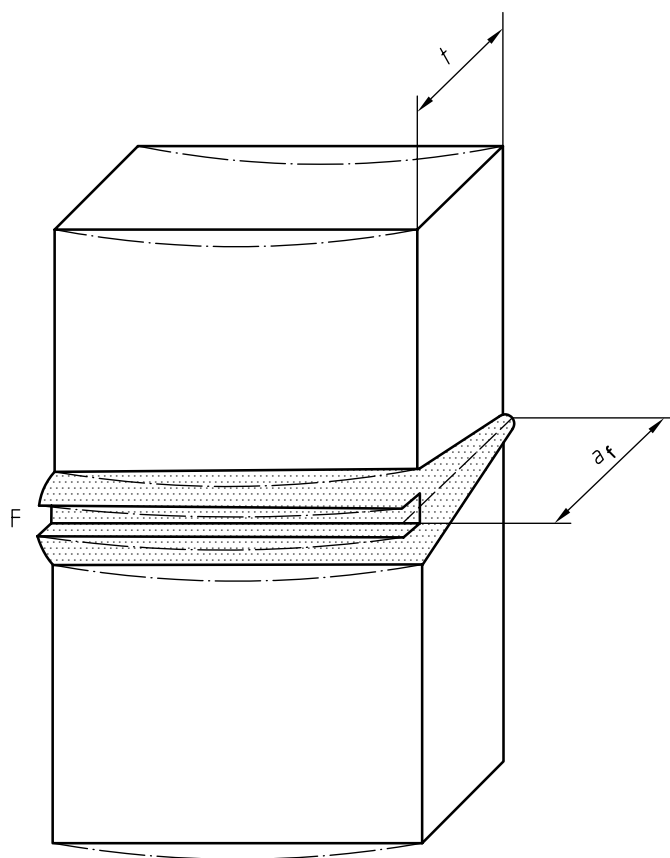


Figure 5 — Notch profiles

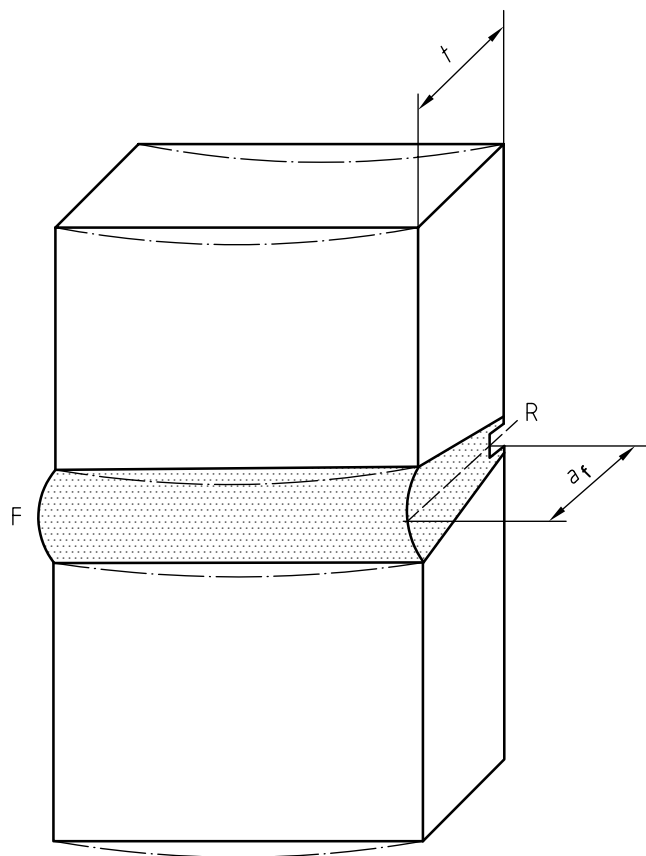


NOTE Full line for plates; chain dotted line for pipes.

Figure 6 — Side notches



a) Face notch



b) Root notch

NOTE Full line for plates; chain dotted line for pipes

Figure 7 — Longitudinal notches in butt welds

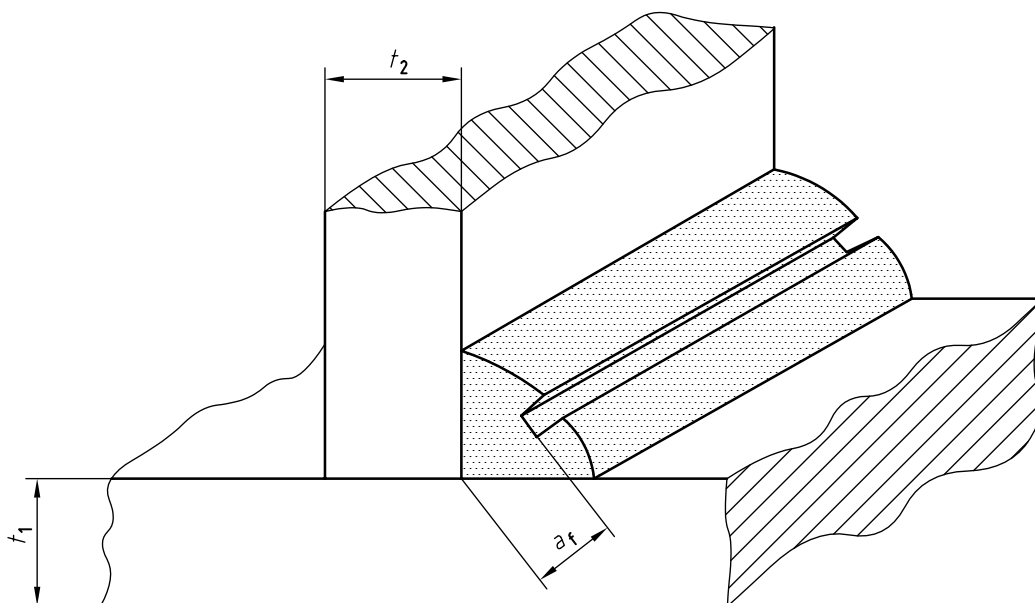


Figure 8 — Longitudinal notch in fillet welds

8 Test procedure

8.1 Butt welds

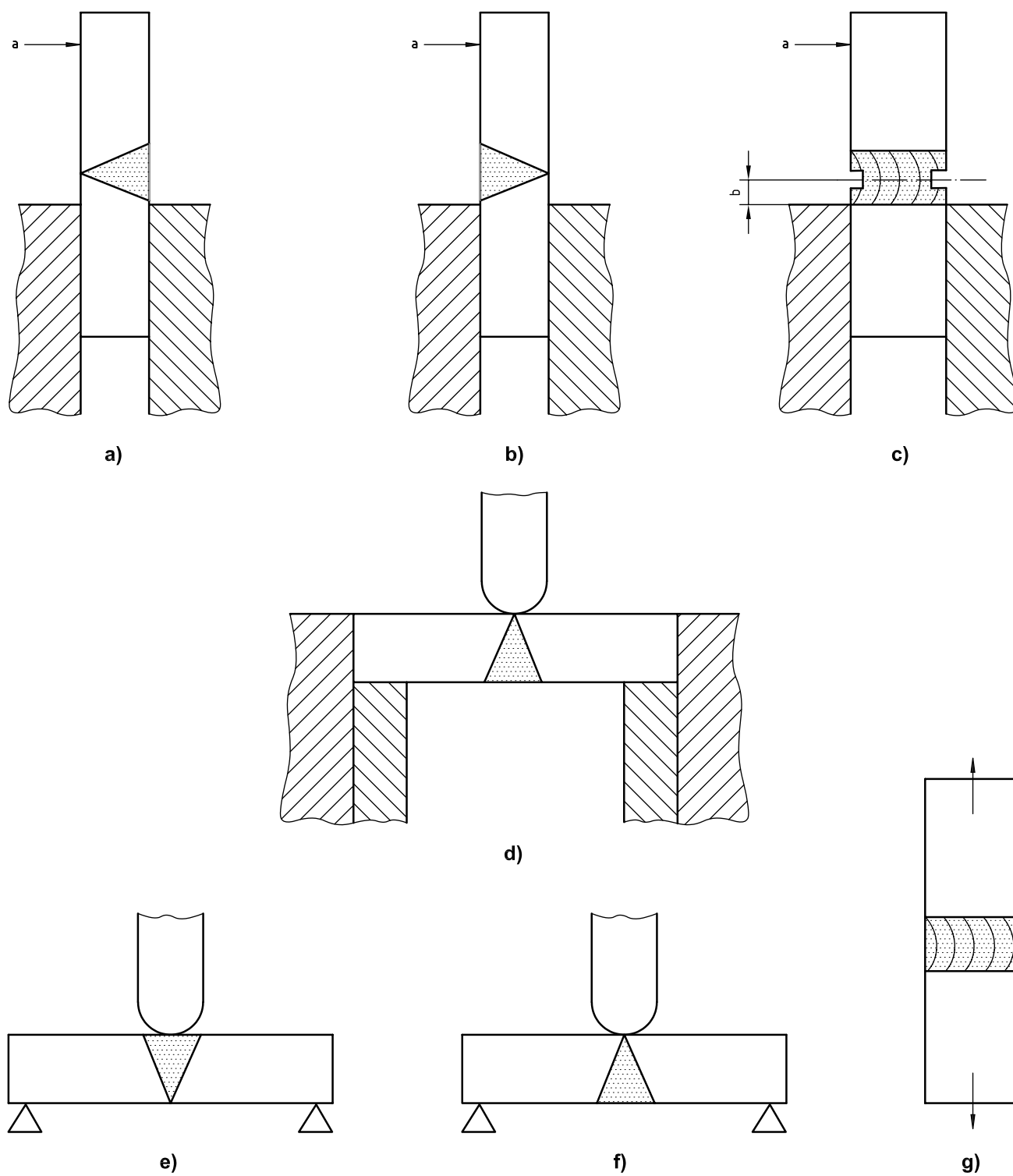
8.1.1 General

Fracture tests may be carried out by:

- dynamic strokes e.g. with a hammer, [see [Figures 9 a\), b\), c\)](#)];
- applying a load by pressing in a vice, bending machine or workshop press [see [Figures 9 d\), e\), f\)](#)];
- applying a load by tension [see [Figure 9 g\)](#)].

For ductile materials, it can be useful to have a minimum distance between the notch and the jaws of the clamping device [see [Figure 9 c\)](#)].

For some materials, it can be useful to test at a low temperature in order to initiate fracture.



Key

- a Impact.
- b See [8.1.1](#).

Figure 9 — Examples of test methods for butt welds (BW) (Notches according to [Figures 5](#) to [7](#))

8.1.2 Thin material

For fracturing thin welded joints alternate bending can be necessary. The limit depends on the ductility of the material. It shall be carried out by pressing the test specimen, close to the notch, in the jaws. If no fracture occurs, straightening and repeated bending shall follow.

Tension testing [see [Figure 9 g\)](#)] may be also used instead of bending. Striking with a hammer is not recommended for fracture tests on thin materials.

8.1.3 Thick material

Thicker materials may be fractured by hammer strokes.

When a bending machine is used, the diameter of the former shall be chosen in such a way that the fracture occurs without the need for alternate bending.

Bending may be carried out either with the weld perpendicular or transverse to the direction of the applied force according to [Figures 9 c\), d\), e\), f\)](#). The lowest limit for the test for aluminium is approximately 8 mm thickness.

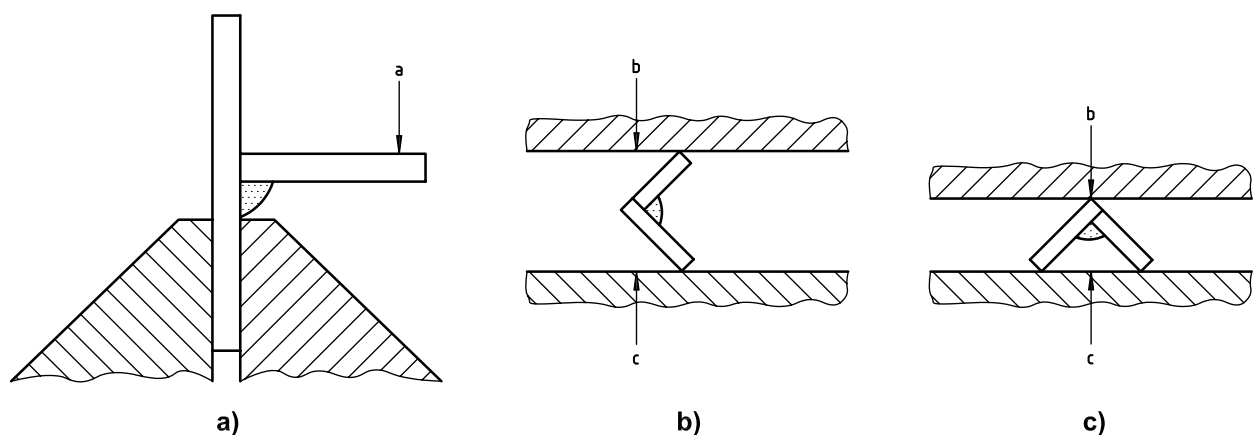
8.2 Fillet welds

Test methods are similar to those for butt welds (see [8.1](#)) except that tension testing is not possible. Examples are given in [Figure 10](#).

8.3 Special recommendations for ductile weld metals

For ductile weld metals such as austenitic steels, aluminium, copper, nickel and their alloys, it can be necessary to restrict the thickness of the test specimen and the throat thickness, increase the width of the notch, decrease the radius of the notch and increase the severity (stroke loading, hammer loading) of the test, if fracture is required in the weld metal.

For ductile weld metals such as ferritic steel, it can be necessary to cool the test specimen.



Key

- a Stroke.
- b Direction of movement.
- c Movement, if applicable.

Figure 10 — Examples of test methods for fillet welds (FW) (Notches according to [Figures 5](#) and [8](#))

9 Test result

The fracture surface shall be examined visually in accordance with ISO 17637. For clear detection and identification of imperfections a low magnifying glass (up to five times) may be used.

A full description of the appearance of the fracture surface and the type and location of any imperfection present shall be reported. It shall be stated that the quality has been evaluated in accordance with ISO 5817 or ISO 10042. The quality level is specified by the application standard or by agreement between the contracting parties.

10 Test report

The test report shall contain the following information:

- a) a reference to this document, i.e. ISO 9017;
- b) the identification of the test specimen;
- c) the specimen denomination in accordance with [Table 1](#);
- d) records of types, locations and sizes of all unacceptable imperfections in accordance with the relevant quality level.

An example of a typical test report is given in [Annex A](#).

Annex A (informative)

Example of a test report

No.

According to pWPS

According to test result "fracture test"

test result "....."

Manufacturer:

Purpose of the examination:

Form of product:

Parent metal:

Consumable:

Denomination of test piece:

Table A.1 — Fracture test in accordance with ISO 9017

Test specimen	Denomination	Results	
		Type and size of imperfections	Quality level

Examiner or examining body: Certified by:

.....

(name, date and signature) (name, date and signature)

