



Non-destructive testing — Ultrasonic testing of austenitic and austenitic-ferritic stainless steels flat products of thickness equal to or greater than 6 mm (reflection method)

The European Standard EN 10307:2001 has the status of a
British Standard

ICS 77.040.20; 77.140.50

National foreword

This British Standard is the official English language version of EN 10307:2001.

The UK participation in its preparation was entrusted to Technical Committee ISE/72, Methods of physical and metallographic testing, which has the responsibility to:

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- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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Non-destructive testing - Ultrasonic testing of austenitic and austenitic-ferritic stainless steels flat products of thickness equal to or greater than 6 mm (reflection method)

Essais non destructifs - Contrôle par ultrasons des produits plats en acier inoxydable austénitique et austéno-ferritique d'épaisseur égale ou supérieure à 6 mm (méthode par réflexion)

Zerstörungsfreie Prüfung - Ultraschallprüfung von Flacherzeugnissen aus austenitischem und austenitisch-ferritischem nichtrostendem Stahl ab 6 mm Dicke (Reflexionsverfahren)

This European Standard was approved by CEN on 30 September 2001.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

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Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 2 "Steel - Physico-chemical and non-destructive testing", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2002, and conflicting national standards shall be withdrawn at the latest by April 2002.

Annex A is informative.

This standard includes a Bibliography.

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1 Scope

This European Standard describes a method for the ultrasonic-testing of uncoated flat austenitic and austenitic-ferritic stainless steel product for internal discontinuities. It is applicable to flat product in nominal thickness range of 6 mm to 200 mm. Mechanised, semi-automatic or automatic techniques may be used but should be agreed between the purchaser and the supplier.

This standard also defines 3 quality classes for the flat product body (classes S₁, S₂ and S₃) and 4 quality classes (E₁, E₂, E₃, E₄) for the edges in accordance with the criteria specified in clause 12.

Other methods of testing, e.g. by transmission technique or other test equipments may be used at the manufacturer's discretion provided that they give equivalent results to those obtained under the conditions of this standard. In the event of a dispute, only the method defined in this standard prevails.

Testing of flat product of thickness less than 6 mm may be the subject of special agreements between the parties concerned.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 473, *Non destructive testing - Qualification and certification of NDT personnel - General principles.*

EN 583-2, *Non-destructive testing – Ultrasonic examination - Part 2 : Sensitivity and range setting.*

EN 583-5, *Non-destructive testing - Ultrasonic examination - Part 5 : Characterization and sizing of discontinuities.*

EN 1330-4, *Non destructive testing - Terminology - Part 4 : Terms used in ultrasonic testing.*

EN 12223; *Non-destructive testing – Ultrasonic examination – Specification for calibration block n°1.*

EN 12668-1, *Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 1 : Instruments.*

EN 12668-2, *Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 2 : Probes.*

EN 12668-3, *Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 3 : Combined equipment.*

3 Terms and definitions

Definitions for general terms of non-destructive testing can be found in other European Standards, e.g. EN 1330-1 and EN 1330-2. For the purposes of this European Standard, the terms and definitions given in EN 1330-4 apply, together with the following :

3.1

internal discontinuity

any imperfection lying within the thickness of the flat product, e.g. planar or laminar imperfection, single-plane or multi-plane inclusion bands or clusters

NOTE It is referred in the text as discontinuity.

3.2**defect**

internal discontinuity, exceeding the specified maximum size or population density limits

3.3**population density**

the number of individual internal discontinuities of a size greater than a specified minimum size and less than a specified maximum size per specified area of body or length of edge zone

3.4**manual testing**

testing by an operator applying an ultrasonic probe, or probes, to the flat product surface, manually executing the appropriate scanning pattern on the flat product surface and assessing ultrasonic signal indications on the electronic equipment screen either by direct viewing or by built-in signal amplitude alarm devices

3.5**automatic and semi-automatic testing**

testing using a mechanized means of applying the ultrasonic probe or probes to, and executing the appropriate scanning pattern on the product surface, together with ultrasonic signal indication evaluation by electronic means

NOTE Such testing can be either fully automatic with no operator involvement, or semi-automatic when the operator performs basic equipment operation functions.

A list of equivalent terms in several European languages is given in annex A.

4 Items for agreements

The following aspects concerning ultrasonic testing shall be agreed between the purchaser and supplier at the time of the enquiry or order :

- a) the manufacturing stage(s) at which ultrasonic testing shall be performed (see clause 10) ;
- b) the volume(s) to be tested and whether grid scanning coverage or complete scanning coverage is required (see clause 13) ;
- c) the Quality Class required, or the Quality Classes and the zones to which they apply (see clause 15) ;
- d) the applicable recording level and acceptance criteria if different from those detailed in Tables 3 to 5 ;
- e) whether any special scanning coverage, equipment or couplant is required in addition to that detailed in clauses 8 and 13 ;
- f) the scanning technique to be used if not manual ;
- g) the techniques to evaluate discontinuities (see clause 15) ;
- h) the technique(s) to be used for setting sensitivity (see clause 12) ;
- i) whether the test is to be conducted in the presence of the purchaser or his representative ;
- j) whether a written procedure shall be submitted for approval by the purchaser (see clause 6).

5 Principle

The method used is based on the reflection of ultrasonic waves (generally longitudinal), the direction of which is approximately perpendicular to the surface of the product. The examination consists of :

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- a) locating and evaluation of discontinuity by comparing the amplitude of the discontinuity echo with the amplitude of the echo of a flat-bottomed hole of a given diameter and located at the same depth as the discontinuity.

NOTE Only those discontinuities giving an echo amplitude equal or greater than that obtained with the reference flat-bottomed hole are taken into consideration ;

- b) determining the area of the discontinuity according to the -6dB beam width technique. The width of the discontinuity shall be determined perpendicular to the rolling direction. The length shall be determined in the rolling direction.

If areas with particular permeability are located, the testing conditions shall be adjusted in order to test these areas with the required sensitivity level.

The examination is carried out during the first ultrasonic scan (first back wall echo) for all the product thicknesses and from one side only.

6 Procedure

The inspection is normally carried out in the place of production or on the premises of the supplier. If specified on the order, the inspection may take place in the presence of the purchaser or his representative ¹⁾.

Ultrasonic testing shall be performed in accordance with a written procedure. Where specified in the enquiry or order, the written procedure shall be submitted to the purchaser for approval prior to testing.

This written procedure shall be in the form of :

- a) a product specification ; or
- b) a procedure written specifically for the application ; or
- c) this European Standard may be used if it is accompanied by examination details specific to the application.

The procedure shall contain the following details as a minimum requirement :

- a) description of the item to be examined ;
- b) reference documents ;
- c) qualification and certification of examination personnel ;
- d) stage of manufacture at which the examination is carried out ;
- e) examination zones specified in terms of the applicable Quality Classes ;
- f) any special preparation of scanning surfaces, if applicable ;
- g) couplant ;
- h) description of examination equipment ;
- i) calibration ;
- j) scanning plan ;
- k) description and sequence of examination operations ;
- l) recording levels ;

1) In this case, all steps should be taken to ensure that the production process is not disturbed.

- m) characterisation of discontinuities ;
- n) acceptance criteria ;
- o) examination report.

7 Personnel qualification

It is assumed that ultrasonic testing is performed by qualified and capable personnel. In order to prove this qualification, it is recommended to certify the personnel in accordance with EN 473 or equivalent.

8 Ultrasonic test equipment

8.1 Instrument

Instrument for manual testing shall feature A-scan presentation and shall comply with the requirements of EN 12668-1.

8.2 Probe

8.2.1 General

The probes for manual testing shall conform to the requirements of EN 12668-2.

The probe shall have a frequency and dimensions such that the required sensitivity can be secured throughout the extent of the test field.

The single transducer probes shall be such that their dead zone is as small as possible, i.e. 15 % of the product thickness or 15 mm whichever is the smaller. The focusing zone of the double transducer probes shall be adapted to the product thickness.

8.2.2 Nominal frequency

The probes shall have a nominal frequency in the range of 1 MHz to 5 MHz. Probes of a nominal frequency that is outside the range of 1 MHz to 5 MHz may be used for automatic or semi-automatic testing and/or when the product exhibits high attenuation provided that the main requirements of this standard are met.

When double transducer probes are used, the barrier separating the two transducers shall be oriented by an angle of 45° to 90° to the scanning direction.

8.2.3 Type of probes

The greatest transducer dimension shall be in the range from 10 mm to 35 mm, unless otherwise agreed.

The type of the probe depends on the thickness of the flat product as given in Table 1 :

Table 1 — Type of probe

Nominal thickness of the flat product t mm	Type of probe
$6 \leq t < 60$	Double transducer probe
$60 \leq t \leq 200$	Single transducer or double transducer probe ^{a b}
<p>^a In the event of a dispute, a single probe shall be used.</p> <p>^b Where automatic testing is carried out using immersion or water column techniques, it is permissible to use normal probes for thickness lower than 60 mm thick.</p>	

8.3 Calibration blocks

Calibration blocks shall conform to the requirements detailed in EN 12223.

8.4 Reference blocks

Reference blocks shall be made from a material having similar acoustic properties to the product to be examined. The surface condition of the reference block shall be representative of the surface condition of the product to be examined. Unless otherwise specified the reference block shall contain at least three reflectors covering the entire depth range under examination.

The bottom of the holes shall be as flat as practicable, parallel to the ultrasound entry surface and free from pits or score marks that significantly degrade its ultrasonic reflectivity. The tolerance on the diameter of the flat-bottomed hole or width of recess shall be $\pm 5\%$.

8.5 Couplant

The couplant used shall be appropriate to the application. The same type of couplant shall be used for calibration, setting sensitivity, scanning and evaluation of discontinuities.

After examination, couplant shall be removed if its presence could adversely affect later manufacturing or inspection operations or the integrity of the product.

NOTE Water is normally used but other coupling media may be used at the discretion of the supplier.

9 Routine calibration and checking

The combined equipment (instrument and probes) for manual testing shall be calibrated and checked in accordance with the requirements detailed in EN 12668-3.

10 Stage of manufacture

Ultrasonic testing shall be performed in the delivery condition unless otherwise agreed at the time of enquiry and order.

11 Surface condition

Scanning surfaces shall be free from paint, non adhering scale, dry couplant, surface irregularities or any other substance, which could reduce coupling efficiency, hinder the free movement of the probe or cause errors in interpretation. The surface condition shall be considered acceptable providing the specified Quality Class can be achieved.

12 Sensitivity setting

Calibration of the ultrasonic test equipment for use particularly requires that the time base, power and amplification be determined according to EN 583-2.

The time base is calibrated to a value at which the distance, on the oscilloscope screen, between the interface echo and back-wall echo is sufficient to allow a defect echo to be clearly detected between them.

The power and amplification shall be calibrated on an area free from discontinuities. The amplitude of the first back-wall echo is set to the maximum screen height.

The system shall be checked at least once every 8 h.

The procedure to be used shall also be in accordance with EN 583-2.

The characterisation curves shall be determined by using steeped reference blocks and shall give :

- a) the change in the amplitude of the back-wall echo as a function of the product thickness ;
- b) the change in the amplitude of the echo of the flat-bottomed hole as a function of its position for holes of diameter :
 - 11 mm for quality classes S_1 , S_2 and E_1 ;
 - 8 mm for quality classes S_2 , S_3 , E_2 and E_3 ;
 - 5 mm for quality classes S_3 and E_4 .

When testing with a double-transducer probe, only the 5 mm diameter hole is used for all the qualities as the characteristic curves corresponding to the 8 mm and 11 mm diameter holes become confused with the curve of the back-wall echo.

According to the family of stainless steel to be tested, the reference blocks with flat-bottomed holes of 11 mm, 8 mm and 5 mm diameter are made of austenitic or austenitic-ferritic stainless steel with a homogenous structure and close acoustic properties to the part to be examined and each curve shall be determined from at least five points distributed over the entire field of use of the probe.

Thus, for a flat product of given thickness, the method consists of adjusting the amplitude of the back-wall echo to the value given by the curve for the variation of the back-wall echo amplitude and comparing the amplitude of the discontinuity echo with the characteristics curves (for 11 mm, 8 mm and 5 mm diameter holes) in accordance with the quality class selected. Only discontinuities for which the amplitude of the echo is greater than that of the characteristic curve shall be taken into account.

If during testing of flat products a fall of the back-wall echo greater than 12 dB is detected without detection of discontinuity echo this setting shall be retaken for testing the relevant area.

13 Scanning

13.1 General

For the flat product body, the testing is based on statistical methods, unless otherwise specified in the order.

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According to the quality class, scanning of the flat product body shall be carried out in accordance with 13.3.1 and/or 13.3.2.

When requested, the edges shall be tested and in addition the areas awaiting welds or further machining.

Figure 1 gives a schematic representation of terms used.

The probe may be :

- either hand held ; or
- mounted on a continuous testing apparatus with a scanning speed sufficiently low for the discontinuities to be easily located taking into account the image retention of the screen ; or
- fitted with a device, which automatically indicates the discontinuity.

13.2 Scanning speed

Manual testing, speed shall not exceed 150 mm/s.

13.3 Testing of the flat product body

13.3.1 Quality class S₁ flat product

Scanning comprises continuous examination along the lines of a grid made of a 200 mm square parallel to the edges of the flat product, or along with parallel or oscillating lines distributed uniformly over the area, giving the same degree of control.

13.3.2 Quality class S₂ and S₃ flat product

Scanning comprises continuous examination along the lines of a grid made of a 100 mm square parallel to the edges of the flat product, or along with parallel or oscillating lines distributed uniformly over the area, giving the same degree of control.

13.4 Testing of the flat product edges

Scanning comprises a full examination of a zone in accordance with Table 2 over the four edges of the flat product.

Table 2 — Zone width for flat product edges

Thickness of the flat product <i>t</i> mm	Zone width mm
$6 \leq t < 50$	50
$50 \leq t < 100$	75
$100 \leq t \leq 200$	100

14 Evaluation of discontinuities

The procedure to be used shall be in accordance with EN 583-5 and with the following.

14.1 Testing the flat product body

14.1.1 Testing with double transducer probes

For discontinuities whose maximum echo amplitude is greater than that of the corresponding 5 mm flat-bottomed hole curve, the area shall be determined in accordance with 5 b).

Delineation consists of determining the area of the discontinuities identified, the contour of the discontinuity being defined by the positions of the centre of the probe corresponding to a defect echo height equal to half the maximum amplitude of the defect echo height of the discontinuity under consideration. Delineation of area is carried out with the same probe or a probe of the same operating conditions as those used for the detection of the discontinuity. For this, it is necessary to mark discontinuities as they are detected.

For the delineation of the discontinuity, the probe is moved in all directions. The width is the dimension determined perpendicularly to the rolling direction, the length is the dimension determined in the rolling direction.

The area of the discontinuity is defined as the product of its length and its width. Two adjacent discontinuities shall be considered as forming a single discontinuity of area of the sum of the two, if the distance separating their contours is :

- equal to or less than the length of the smaller of the two for discontinuities in line ;
- equal to or less than the width of the smaller of the two for adjacent discontinuities.

14.1.2 Testing with single transducer probes

The test consists of :

- a) for quality class S_1 flat product : determination of the area according to -6 dB technique in 14.1.1 ;
- b) for quality class S_2 and S_3 flat product : counting of the discontinuities which can be done when they are detected using the characteristic curves for 5, 8 and 11 mm diameter holes.

The following elements are thus determined :

- for quality class S_2 : the number of discontinuities giving echoes with an amplitude greater than the 11 mm diameter curve and the number N_2 of discontinuities (Table 4) giving echoes with an amplitude between characteristic curves for the 8 mm and 11 mm diameter holes ;
- for quality class S_3 : the number of discontinuities giving echoes with an amplitude greater than the 8 mm diameter curve and the number N_3 of discontinuities (Table 4) giving echoes with an amplitude between characteristic curves for the 5 mm and 8 mm diameter holes.

14.2 Testing the edges

The test consists of scanning the total area of the edges (or areas to be welded according to sketches) where discontinuities were located defined in 8.3 under the same conditions as for flat product body (14.1).

The following elements are determined :

- the maximum dimension (L_{max}) and minimum dimension (L_{min}) of the discontinuity in the directions parallel to the edges of the flat product ;
- the area (S) ($L_{max} \times L_{min}$) of the discontinuity ;
- the number of discontinuities per 1m length smaller than the maximum area (S_{max}) and longer than the recording level (L).

The determination of these properties of the discontinuity is obtained using the -6 dB method.

15 Recording level and acceptance criteria

Several Quality Classes may be applied to Ultrasonic testing of austenitic and austenitic-ferritic stainless steels flat products broad flanged beams with parallel flanges and IPE beams. The applicable Quality Class(es) shall be agreed between the purchaser and supplier.

Tables 3, 4 and 5 detail the recording level and acceptance criteria which should be applied to three Quality Classes (S_1 , S_2 , S_3) for the flat product body, depending on the type of probe used and to four Quality Class (E_1 , E_2 , E_3 , E_4) for flat product edge.

Table 3 — Acceptance criteria for testing with double transducer probes for the body of flat products

Quality class	Acceptance limit of the area S for individual discontinuity mm ²	Acceptance criteria for discontinuities	
		Area ^a considered mm ²	Maximum number in the most populated area per square meter
S_1	$S < 1\ 000$	$100 < S \leq 1\ 000$	15 in the most populated 1 m x 1 m square
S_2	$S < 100$	$50 < S \leq 100$	10 in the most populated 1 m x 1 m square
S_3	$S < 50$	$20 < S \leq 50$	10 in the most populated 1 m x 1 m square

^a Area of each discontinuity in the cluster in question (see 14.1).

NOTE This table can be used for thicknesses ≥ 60 mm if an appropriate method other than the - 6 dB method is used for the sizing of discontinuities.

Table 4 — Acceptance criteria for testing with normal probes for the body of flat products

Quality class	Acceptance limit of the area S for individual discontinuity	Acceptance criteria for discontinuities	
		Area ^a or echo amplitude considered	Maximum number in the most populated per square meter
S_1	$S < 1\ 000$ mm ²	$100 < S \leq 1\ 000$ mm ²	15 in the most populated 1 m x 1 m square
S_2	flaw echo with an amplitude equal or less to the characteristic curve of 11 mm diameter hole	N_2^b (flaw echo amplitude between the characteristic curves of 8 mm and of 11 mm diameter hole)	10 in the most populated 1 m x 1 m square
S_3	flaw echo with an amplitude equal or less to the characteristic curve of 8 mm diameter hole	N_3^c (flaw echo amplitude between the characteristic curves of 5 mm and of 8 mm diameter hole)	10 in the most populated 1 m x 1 m square

^a Area of each discontinuity in the cluster in question (see 14.1).

^b N_2 : Number of discontinuities giving echoes with an amplitude between the characteristics curves for 8 mm and 11 mm diameter holes.

^c N_3 : Number of discontinuities giving echoes with an amplitude between the characteristics curves for 5 mm and 8 mm diameter holes.

Table 5 — Acceptance criteria for (flat product) edge zone testing

Quality class	Recording level <i>L</i> mm	Acceptance criteria		
		Permissible individual discontinuity size		Maximum number of discontinuities smaller than the maximum area S_{max} and longer than L per 1 m length
		Maximum Dimension L_{max} mm	Maximum Area S_{max} mm ²	
E ₁	50	1 000	25	5
E ₂	40	500	20	4
E ₃	30	100	15	3
E ₄	20	50	10	2

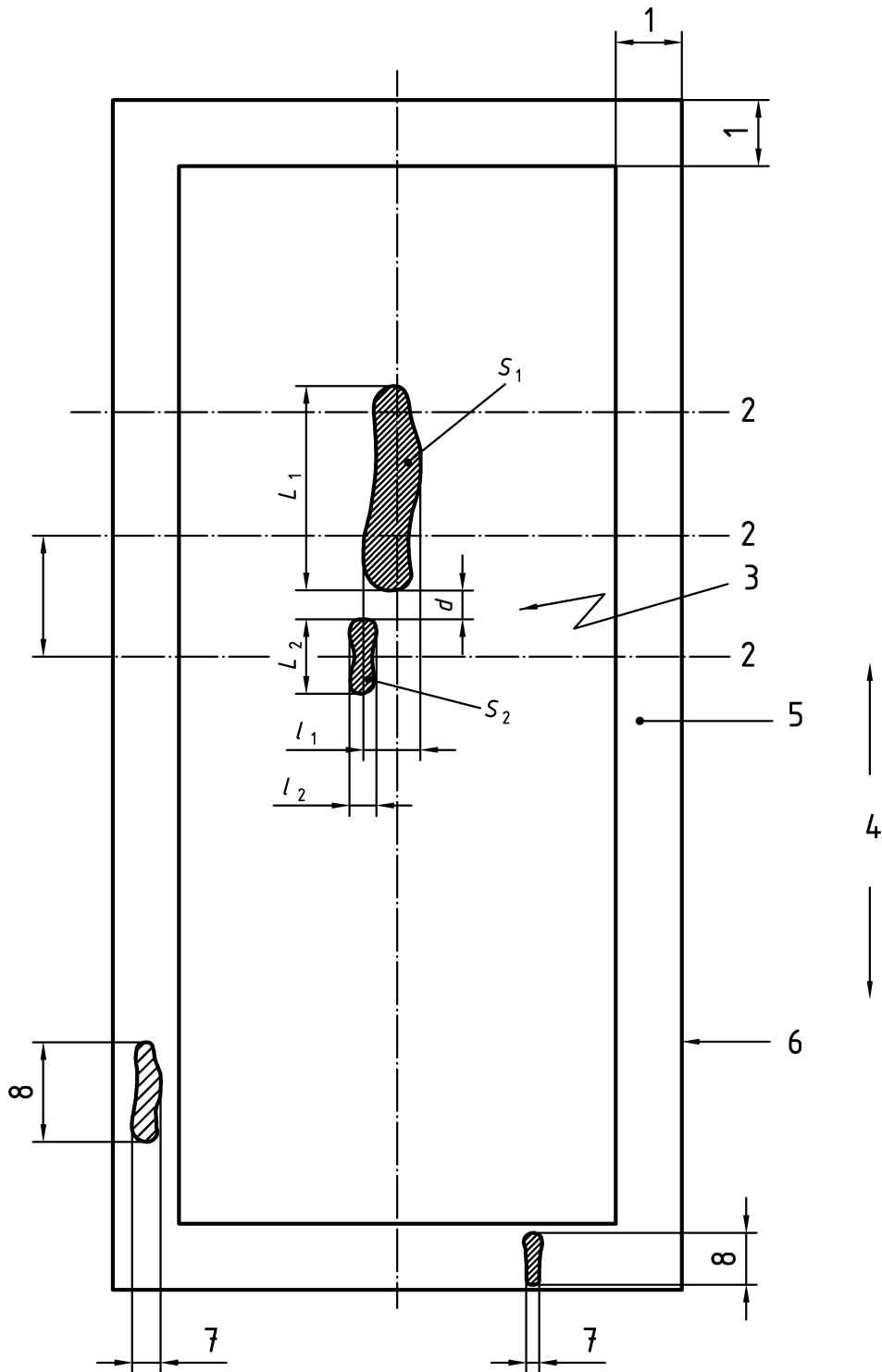
NOTE For product with thickness ≥ 60 mm, a counting of the discontinuities is carried out using the characteristics curves for the 11 mm, 8 mm and 5 mm diameters holes :

- **quality class E₃**: number of discontinuities giving echoes with an amplitude between characteristic curves for the 8 mm and 11 mm diameter holes : 3 ;
- **quality class E₄** : number of discontinuities giving echoes with an amplitude between characteristic curves for the 5 mm and 8 mm diameter holes : 2.

16 Test report

The test report shall include the following information as a minimum requirement :

- a) name of supplier ;
- b) order number ;
- c) identification of product(s) under examination ;
- d) scope of examination : examination zones and applicable Quality Classes ;
- e) stage of manufacture at which ultrasonic testing was performed ;
- f) surface condition ;
- g) equipment used (instrument, probes, calibration and reference blocks) ;
- h) technique(s) used to set sensitivity ;
- i) reference to this standard or reference to the written procedure used (where applicable) ;
- j) results of examination : location, classification of all discontinuities exceeding the appropriate recording level ;
- k) details of any restrictions to the scanning coverage ;
- l) date of examination ;
- m) name, qualification and signature of operator.



key

- | | | | |
|---|--|---|--------------|
| 1 | See Table 2 for the value of the edge zone width | 5 | Edge zone |
| 2 | Scan line | 6 | Flat product |
| 3 | If $d \leq L_2$ then $S = S_1 + S_2$ | 7 | Width |
| 4 | Principal rolling direction | 8 | Length |

Figure 1 — Schematic representation of terms used

Annex A (informative)

List of equivalent terms in several European languages

English	French	German	Italian	Dutch
Time base	Base de temps	Zeitbasis	Base dei tempi	Tijdbasis
Noise signal	Bruit de fond	Rauschanzeige	Rumore di fondo	Ruis
Discontinuity echo	Echo de défaut	Fehlerecho	Eco del difetto	Foutecho
Back-wall echo	Echo de fond	Rückwandecho	Eco di fondo	Bodemecho
Probe	Transducteur	Prüfkopf	Sonda	Taster
Double transducer probe	Transducteur à émetteur et récepteur séparés	SE-Prüfkopf	Sonda ed emettitore e ricevitore separati (sonda doppia)	Dubbel-kristaltaster
Single transducer probe	Transducteur droit	Einschwinger – Prüfkopf	Sonda normale	Rechtetaster
Transducer	Transducteur	Schwinger	Transduttore	Kristal
Flat-bottomed hole	Trou à fond plat	Flachbodenbohrung	Foro a fondo piatto	Vlakbodemgat
Dead zone	Zone morte	Tote Zone	Zona morta	Dode zone

Bibliography

- [1] EN 1330-1, *Non destructive testing - Terminology - Part 1 : List of general terms.*
- [2] EN 1330-2, *Non destructive testing - Terminology - Part 2 : Terms common to the non-destructive testing methods.*

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