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Steel castings — Ultrasonic examination —

Part 1: Steel castings for general purposes

Pièces moulées en acier — Contrôle aux ultrasons —

Partie 1: Pièces moulées en acier pour usages généraux

Reference number
ISO 4992-1:2006(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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4992-1 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 11, *Steel castings*.

ISO 4992 consists of the following parts, under the general title *Steel castings — Ultrasonic examination*:

— *Part 1: Steel castings for general purposes*

— *Part 2: Steel castings for highly stressed components*

Steel castings — Ultrasonic examination —

Part 1:
Steel castings for general purposes

1 Scope

This part of ISO 4992 specifies the requirements for the ultrasonic examination of steel castings (with ferritic structure) for general purposes, and the methods for determining internal discontinuities by the pulse-echo technique.

This part of ISO 4992 applies to the ultrasonic examination of steel castings which have usually received a grain-refining heat treatment and which have wall thicknesses up to and including 600 mm. For greater wall thicknesses, special agreements apply with respect to the test procedure and recording levels.

This part of ISO 4992 does not apply to austenitic steels and joint welds.

2 Normative references

The following referenced documents are indispensable for the application 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 5577, *Non-destructive testing — Ultrasonic inspection — Vocabulary*

ISO 7963, *Non-destructive testing — Ultrasonic testing — Specification for calibration block No. 2*

EN 583-1, *Non-destructive testing — Ultrasonic examination — Part 1: 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 No. 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

For the purposes of this document, the terms and definitions given in ISO 5577, EN 583-1, EN 583-2, EN 583-5, and EN 1330-4, and the following, apply.

3.1
reference discontinuity echo size
smallest indication to be recorded during the assessment phase of an ultrasonic examination, usually expressed as an equivalent flat-bottomed hole diameter

3.2
point discontinuity
discontinuity, the dimensions of which are smaller than or equal to the sound-beam width

NOTE Dimensions in this part of ISO 4992 relate to length, width and/or dimension in the through-wall direction.

3.3
complex discontinuity
discontinuity, the dimensions of which are larger than the sound-beam width

NOTE Dimensions in this part of ISO 4992 relate to length, width and/or dimension in the through-wall direction.

3.4
planar discontinuity
discontinuity having two measurable dimensions

3.5
volumetric discontinuity
discontinuity having three measurable dimensions

3.6
special rim zone
outer rim-zone part with special requirements

NOTE Examples of special requirements are machined surfaces, higher stresses and sealing surfaces.

3.7
production welding
any welding carried out during manufacturing before final delivery to the purchaser

3.7.1
joint welding
production welding used to assemble components together to obtain an integral unit

3.7.2
finishing welding
production welding carried out in order to ensure the agreed quality of the casting

4 Requirements

4.1 Order information

The following information shall be available at the time of enquiry and order (see also EN 583-1):

— the areas of the casting and the number or percentage of castings to which the ultrasonic examination requirements apply (examination volume, extent of examination);

— the severity level to be applied to the various zones or areas of the casting (acceptance criteria);

— requirements for a written examination procedure;

— whether there are any additional requirements for the examination procedure, see also 5.5.1.

4.2 Extent of examination

The casting shall be examined so that the agreed areas are totally covered (insofar as this is possible from the shape of the casting) by the use of the best applicable examination technique.

For wall thicknesses greater than 600 mm, agreement shall be made between the parties concerned on the examination procedure and also on the recording and acceptance levels.

4.3 Maximum permissible size of discontinuities

4.3.1 Limits of acceptance for planar discontinuities mainly orientated perpendicular to the surface

The limits of acceptance for planar discontinuities are given in Figure 1.

Indications with measurable dimensions are not permissible as severity level 1.

The largest dimension in the through-wall direction shall not exceed 10 % of wall thickness, except indications with a measurable length $\leqslant$ 10 mm. Such indications shall not exceed a dimension in the through-wall direction of 25 % of wall thickness or 20 mm.

The greatest distance between indications, as a criterion for evaluation as a single indication or indication area perpendicular or lateral to the surface, shall be 10 mm.

For an area with a measurable length and non-measurable dimension in the through-wall direction, this non-measurable dimension shall be taken as 3 mm and the area shall be calculated as follows:

$$A = 3 \times L \quad (1)$$

where

— A is the area of indication, in square millimetres;

— 3 is the width taken, in millimetres;

— L is the measurable length, in millimetres.

4.3.2 Limits of acceptance for volumetric discontinuities

The limits of acceptance for volumetric discontinuities are given in Table 1. Any discontinuity exceeding one of the criteria shall be considered as unacceptable.

4.3.3 Maximum permissible discontinuities in the case of radiographic examination of the casting carried out as a supplement to ultrasonic examination

Unless otherwise agreed by the time of enquiry and order, when, after conducting the radiographic and the ultrasonic examination in combination, it has been demonstrated that a discontinuity is situated in the core zone, this additional information makes the discontinuity acceptable at one level less severe, e.g. severity level 3 instead of 2 for radiographic examination, see EN 1559-2.

4.4 Personnel qualification

It is assumed that ultrasonic examination is performed by qualified and capable personnel. In order to prove this qualification, it is recommended to certify personnel according to ISO 9712 or EN 473.

4.5 Wall-section zones

The wall section shall be divided into zones as shown in Figure 2. These sections relate to the dimensions of the casting ready for assembly (finish machined).

4.6 Severity levels

If the purchaser specifies different severity levels in different areas of the same casting, all of these areas shall be clearly identified on the purchaser's drawing and shall include:

— all necessary dimensions for accurate location of zones;

— the full extent of all weld preparations and the thickness of any special rim zone.

Severity level 1 is only applied to weld preparations and special rim zones.

Unless other requirements have been agreed by the time of acceptance of the order, for finishing welds, the requirements for the parent metal shall apply.

5 Examination

5.1 Principles

The principles of ultrasonic examination given in EN 583-1, EN 583-2 and EN 583-5 shall apply.

5.2 Material

The suitability of material for ultrasonic examination is assessed by comparison with the echo height of a reference reflector (usually the first backwall echo) and the noise signal. This assessment shall be carried out on selected casting areas which are representative of the surface finish and of the total thickness range. The assessment areas shall have parallel surfaces.

The reference echo height according to Table 2 shall be at least 6 dB above the noise signal.

If the echo height of this smallest detectable flat-bottomed or equivalent side-drilled hole diameter at the end of the test range to be assessed is less than 6 dB above the grass level, then the ultrasonic testability is reduced. In this case, the flat-bottomed or side-drilled hole diameter which can be detected with a signal-noise ratio of at least 6 dB shall be noted in the test report, and the additional procedure shall be agreed between the manufacturer and the purchaser.

NOTE For the definition of an adequate flat-bottomed hole size, the distance gain size system (DGS) or a test block of identical material, heat treatment condition and section thickness containing flat-bottomed holes with a diameter according to Table 2 or equivalent side-drilled holes, can be used. The following formula is used for converting the flat-bottomed hole diameter into the side-drilled hole diameter:

$$D_{\mathrm{Q}} = \frac{4{,}935 \times D_{\mathrm{FBH}}^{4}}{\lambda^{2} \times s} \qquad (2)$$

where

D_{Q} is the side-drilled hole diameter, in millimetres;

D_{FBH} is the flat-bottomed hole diameter, in millimetres;

λ is the wave length, in millimetres;

s is the path length, in millimetres.

The formula is applicable for $D_Q \geqslant 2\lambda$ and $s \geqslant 5 \times$ near-field length and is only defined for single element probes.

5.3 Equipment and coupling medium

5.3.1 Ultrasonic instrument

The ultrasonic instrument shall meet the requirements given in EN 12668-1 and shall have the following characteristics:

— range setting, from at least 10 mm to 2 m continuously selectable, for longitudinal and transverse waves transmitted in steel;

— gain, adjustable in 2 dB maximum steps over a range of at least 80 dB with a measuring accuracy of 1 dB;

— time-base and vertical linearities less than 5 % of the adjustment range of the screen;

— suitability, at least for nominal frequencies from 1 MHz up to and including 5 MHz, in the pulse-echo technique with single-crystal and twin-crystal probes.

5.3.2 Probes and transducer frequencies

The probes and transducer frequencies shall be as given in EN 12668-2 and EN 12668-3 with the following exceptions:

— nominal frequencies shall be in the range 1 MHz to 5 MHz;

— for oblique incidence, angle probes with angles between 35° and 70° shall be used.

NOTE Normal or angle probes can be used for the examination of steel castings. The type of probe used depends on the geometry of the casting and the type of discontinuity to be detected.

For examining zones close to the surface, twin-crystal probes (normal or angle) should be preferred.

5.3.3 Checking the ultrasonic examination equipment

The ultrasonic examination equipment shall be checked regularly by the operator in accordance with EN 12668-3.

5.3.4 Coupling medium

A coupling medium in accordance with EN 583-1 shall be used. The coupling medium shall wet the examination area to ensure satisfactory sound transmission. The same coupling medium shall be used for calibration and all subsequent examination operations.

NOTE The sound transmission can be checked by ensuring one or more stable backwall echoes in areas with parallel surfaces.

5.4 Preparation of casting surfaces for examination

For the preparation of casting surfaces for examination, see EN 583-1.

The casting surfaces to be examined shall be such that satisfactory coupling with the probe can be achieved.

In the case of single-crystal probes, satisfactory coupling can be achieved if the condition of the surfaces to be examined corresponds at least to the limit comparator 4 S1 or 4 S2 according to EN 1370.

The roughness of any machined surface to be examined shall be $R_a \leqslant$ 12,5 µm.

For special techniques, higher surface qualities such as 2 S1, 2 S2 (see EN 1370) and $R_a \leqslant$ 6,3 µm can be necessary.

5.5 Examination procedure

5.5.1 General

Because the choice of both the direction of incidence and suitable probes largely depends on the shape of the casting, or on the possible casting discontinuities or on the possible discontinuities from finishing welding, the applicable examination procedure shall be specified by the manufacturer of the casting. In special cases, specific agreements can be made.

If possible, the areas to be tested shall be examined from both sides. When testing from one side only, short-range resolving probes shall be used additionally for the detection of discontinuities close to the surface. Testing with twin-crystal probes is only adequate for wall thicknesses up to 50 mm.

Additionally, when not otherwise agreed between the purchaser and the manufacturer, for all castings, twin-crystal normal and/or angle probes shall be used to examine the following areas up to a depth of 50 mm:

— critical areas, e.g. fillets, changes in cross-section, areas with external chills;

— finishing welds;

— weld preparation areas, as specified in the order;

— special rim zones, as specified in the order, critical for the performance of the casting.

Finishing welds which are deeper than 50 mm shall be subject to supplementary examination with other suitable angle probes.

For angle probes with angles over 60°, the sound beam path shall not exceed 150 mm.

Complete coverage of all areas specified for examination shall be conducted by carrying out systematically overlapping scans.

The scanning rate shall not exceed 150 mm/s.

5.5.2 Range setting

Range setting shall be carried out in accordance with EN 583-2 on the screen of the test instrument, using normal or angle probes in accordance with one of the three options given below:

— with the calibration block No. 1 in accordance with EN 12223, or No. 2 in accordance with ISO 7963;

— with an alternative calibration block made of a material exhibiting similar acoustic properties to those of the material to be examined;

— on the casting itself when using normal probes. In this case, the casting to be tested shall have parallel surfaces, the distance between which shall be measured.

5.5.3 Sensitivity setting

5.5.3.1 General

Sensitivity setting shall be carried out after range setting (see 5.5.2) in accordance with EN 583-2. One of the two following techniques shall be used:

— Distance-amplitude correction curve technique (DAC)

  The distance-amplitude correction curve technique makes use of the echo-heights of a series of identical reflectors (flat-bottomed holes FBH or side-drilled holes SDH), each reflector having a different sound-beam path.

  NOTE A frequency of 2 MHz and a diameter of 6 mm for the flat-bottomed holes are most commonly used.

— Distance gain size technique (DGS)

  The distance gain size technique makes use of a series of theoretically derived curves which link the sound-beam path, the apparatus gain and the diameter of a disc-shaped reflector which is perpendicular to the beam axis.

5.5.3.2 Transfer correction

The transfer correction shall be determined in accordance with EN 583-2.

When calibration blocks are used, transfer correction can be necessary. When determining the transfer correction, consideration shall be given not only to the quality of the coupling surface but also to that of the opposite surface, because the opposite surface also influences the height of the backwall echo (used for calibration). If the opposite surface is machined or complies at least to the limit comparator 4 S1 or 4 S2 according to EN 1370, this surface has a quality which is sufficient for transfer correction measurements.

5.5.3.3 Discontinuity detection

For discontinuity detection, the gain shall be increased until the noise level becomes visible on the screen (search sensitivity).

The echo heights of the flat-bottomed holes given in Table 2, or of the equivalent side-drilled holes, shall be at least 40 % of the screen height at the end of the thickness range to be tested.

If, during examination, suspicion arises that the reduction of backwall-echo indication exceeds the recordable value (see Table 3), testing shall be repeated using locally reduced test sensitivity and the reduction of backwall-echo indication shall be determined quantitatively in decibels.

The sensitivity setting of angle-beam probes shall be such that the typical dynamic echo pattern of these reflectors (see Figure 3) is clearly visible on the screen.

It is recommended that the sensitivity setting of angle-beam probes is verified on real (not artificial) planar discontinuities (cracks with dimensions in the through-wall direction) or on walls perpendicular to the surface and infinite to the sound beam. In these circumstances, the probe shoe should be contoured to fit the casting shape (see EN 583-2).

5.5.4 Consideration of various types of indications

The following types of indications can occur separately or jointly during the examination of castings and shall be observed and evaluated:

— reductions of backwall echo which are not due to the casting shape or the coupling;

— echo indications of discontinuities.

The reduction of backwall echo is expressed in decibels as the drop of the backwall-echo height. The height of the echo indication is given as the flat-bottomed or side-drilled hole diameter.

5.5.5 Recording and recording limits

Unless otherwise specified, all backwall-echo reductions or echo heights reaching or exceeding the levels given in Table 3 shall be recorded.

When using transverse wave probes, irrespective of amplitude, all indications which display travelling characteristics or have an apparent dimension in the through-wall direction shall be recorded for subsequent assessment in accordance with 5.5.7.2.

Each location, where indications to be recorded have been found, shall be marked and indicated in the test report. The location of reflection points shall be documented, e.g. by a sketch or photograph.

5.5.6 Investigation of indications to be recorded

The locations where indications to be recorded have been found (see 5.5.5) shall be investigated more closely with respect to their type, shape, size and position. This investigation can be achieved by altering the ultrasonic test technique (e.g. changing the angle of incidence) or by additionally carrying out radiographic examination.

5.5.7 Characterization and sizing of discontinuities

5.5.7.1 General

For characterization and sizing of discontinuities, see EN 583-5.

The ultrasonic determination of the dimensions of a discontinuity with an accuracy sufficient for engineering applications is only possible under certain preconditions (e.g. knowledge of the type of discontinuity, simple geometry of the discontinuity and optimum impact of the sound beam on the discontinuity).

The characterization of the type of discontinuities can be improved by using additional sound directions and angles of incidence. For a simplification of the procedure, the following categorizations of discontinuities are made:

— discontinuities without measurable dimensions (point discontinuities);

— discontinuities with measurable dimensions (complex discontinuities).

NOTE 1 Annex A gives information on sound-beam diameters, in order to distinguish between discontinuities with or without measurable dimensions.

NOTE 2 Annex B gives information on types of indications and on the determination of their dimensions. It also gives information on range setting (see 5.5.2) and on sensitivity setting (see 5.5.3).

For the determination of the dimensions of discontinuities, it is recommended that probes having a sound-beam diameter as small as possible at the location of the discontinuity are used.

5.5.7.2 Sizing of discontinuities mainly parallel to the test surface

The boundaries of any discontinuity shall be defined by the perimeter line at which the signal amplitude falls to 6 dB below the last maximum or at which, in the case of backwall-echo reduction, the echo is reduced by 6 dB (2 MHz probe) below the height of the undisturbed backwall echo.

The dimension in the through-wall direction of the discontinuity should be measured according to Figure 4.

5.5.7.3 Sizing of discontinuities in the through-wall direction

The sizing of planar discontinuities and their assessment, in relation to specified severity levels, shall be carried out by the probe movement in accordance with 5.5.7.1, but in this case, the echo is reduced by 20 dB (see Figure 3).

5.6 Examination report

The examination report shall contain at least the following information:

- a reference to this part of ISO 4992;
- characteristic data of the examined casting;
- extent of examination;
- type of examination equipment used;
- probes used;
- the examination technique, with reference to the examination area;
- all data necessary for sensitivity setting;
- information on all characteristic features of discontinuities to be recorded (e.g. backwall-echo reduction, position and dimension in the through-wall direction, length, area and flat-bottomed hole diameter) and the descriptions of their position (sketch or photograph);
- date of the examination and name of the responsible person.

Table 1 — Acceptance limits for volumetric discontinuities

Feature	Unit	Zone (see Figure 2)	Severity level												
			1	2			3			4			5		
Casting wall thickness at the examined area	mm		—	⩽ 50	> 50 ⩽ 100	> 100 ⩽ 600	⩽ 50	> 50 ⩽ 100	> 100 ⩽ 600	⩽ 50	> 50 ⩽ 100	> 100 ⩽ 600	⩽ 50	> 50 ⩽ 100	> 100 ⩽ 600
Reflectors without measurable dimension															
Largest diameter of equivalent flat-bottomed hole	mm	rim zone	3	a									not used as criterion		
		core zone													
Number of discontinuities to be recorded in a frame 100 mm × 100 mm	—	rim zone	3[b]	3	5		6		6	not used as criterion					
		core zone		not used as criterion											
Reflectors with measurable dimension															
Largest diameter of equivalent flat-bottomed hole	mm	rim zone	3	a									not used as criterion		
		core zone													
Maximum values of dimension in the through-wall direction of discontinuities	—	rim zone	not permitted	15 % of zone thickness									20 % of zone thickness		
		core zone		15 % of wall thickness									20 % of wall thickness		
Maximum length without measurable width	mm	rim zone		75	75	75	75	75	75	75	75	75	75	75	75
		core zone		75	75	100	75	75	120	100	100	150	100	100	150
Largest individual area [c, d]	mm^2	rim zone		600	1 000	1 000	600	2 000	2 000	2 000	2 000	2 000	3 000	4 000	4 000
		core zone		10 000	10 000	15 000	15 000	15 000	20 000	15 000	15 000	20 000	20 000	30 000	40 000
Largest total area for a reference area [c]	mm^2	rim zone		10 000	10 000	10 000	10 000	10 000	10 000	10 000	15 000	15 000	15 000	20 000	20 000
		core zone		10 000	15 000	15 000	15 000	20 000	20 000	15 000	20 000	20 000	30 000	40 000	40 000
Reference area	mm^2	—		150 000 ≈ (390 mm × 390 mm)			100 000 ≈ (320 mm × 320 mm)								

a For wall thicknesses not greater than 50 mm, flat-bottomed holes exceeding 8 mm diameter are unacceptable.

For wall thicknesses greater than 50 mm, the acceptability of flat-bottomed holes exceeding 8 mm diameter in the rim zone shall be agreed between the manufacturer and the purchaser.

b Accumulated in core zone and rim zone.

c Indications less than 25 mm apart shall be considered as one discontinuity.

d If the indication in the core zone is caused by an individual reflector, the thickness of which does not exceed 10 % of the wall thickness, (e.g. centreline shrinkage), then, in the case of severity levels 2 to 4, values 50 % higher than those specified in this table are acceptable, and in the case of severity level 5, no limit is specified.

Table 2 — Ultrasonic testability requirements

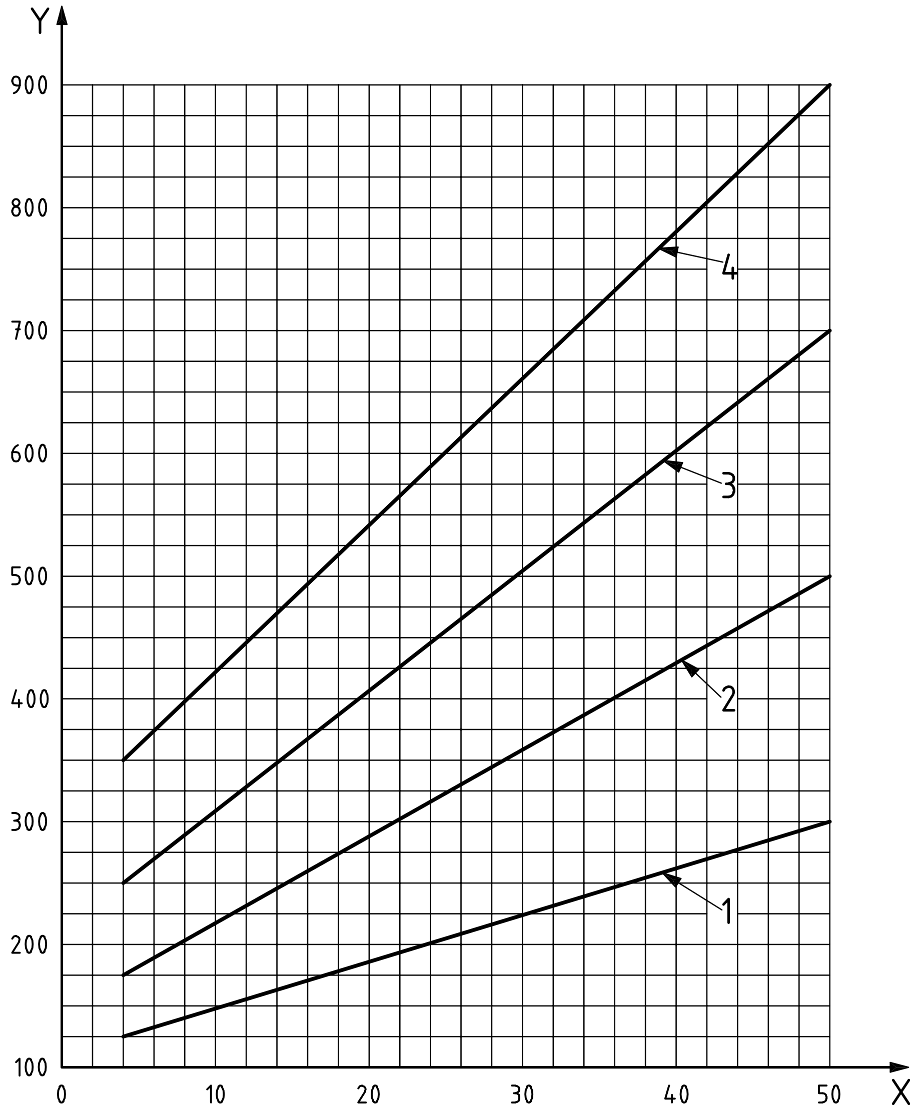
Dimensions in millimetres

Wall thickness	Smallest flat-bottomed hole diameter detectable according to 5.2
⩽ 300	3
> 300 to ⩽ 400	4
> 400 to ⩽ 600	6

Table 3 — Recording levels

Wall thickness mm	Tested area	Reflectors without measurable dimension Diameter of the equivalent flat-bottomed hole[a] min. mm	Reflectors with measurable dimension Diameter of the equivalent flat-bottomed hole[a] min. mm	Reduction of backwall echo min. dB
⩽ 300	—	4	3	12
> 300 to ⩽ 400	—	6	4	
> 400 to ⩽ 600	—	6	6	
—	Areas with severity level 1	3	3	6
—	Special rim zone	3	3	—

[a] For the formula for converting the flat-bottomed hole diameter into the side-drilled hole diameter, see the note to 5.2.



Key

1 Severity level 2

2 Severity level 3

3 Severity level 4

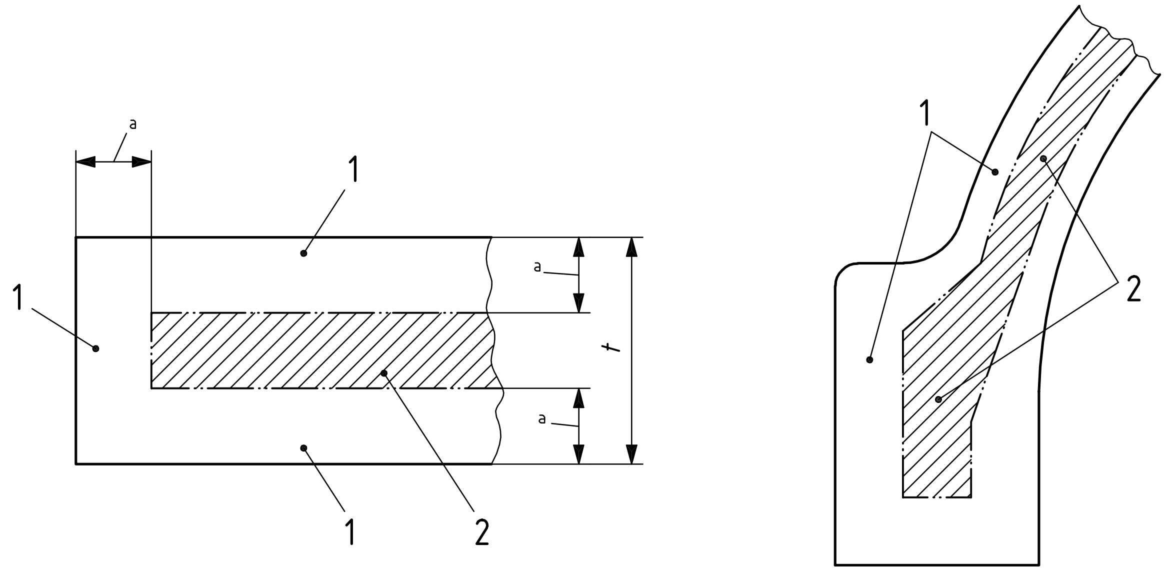
4 Severity level 5

X Distance from test surface, in millimetres.

Y Largest acceptable individual indication area, in square millimetres.

Indications with measurable dimensions are not permissible as severity level 1.

Figure 1 — Acceptance limits for individual planar indications mainly orientated in the through-wall direction, detected with angle probes



Key

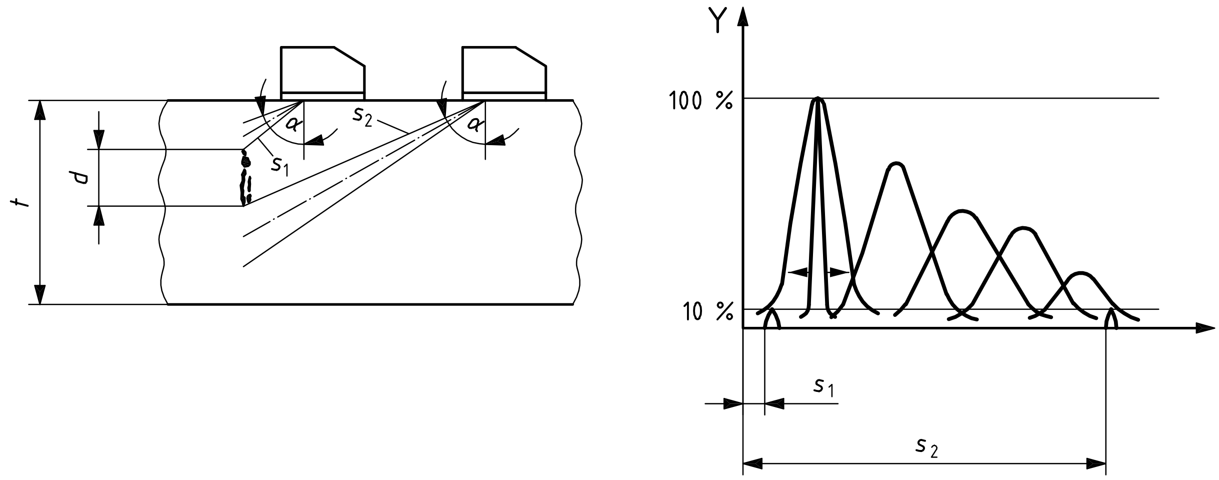
1 Rim zone

2 Core zone

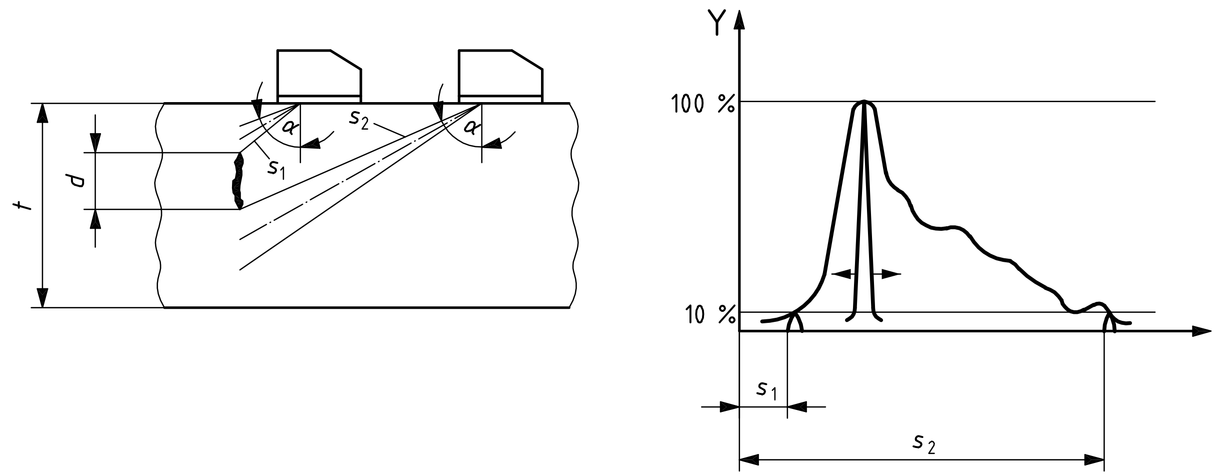
t Wall thickness

[a] *t/3* (max. 30 mm)

Figure 2 — Division of wall section into zones



a) Interrupted reflector



b) Uninterrupted reflector

Key

d Dimension in the through-wall direction

s_1, s_2 Length of the sound-beam path

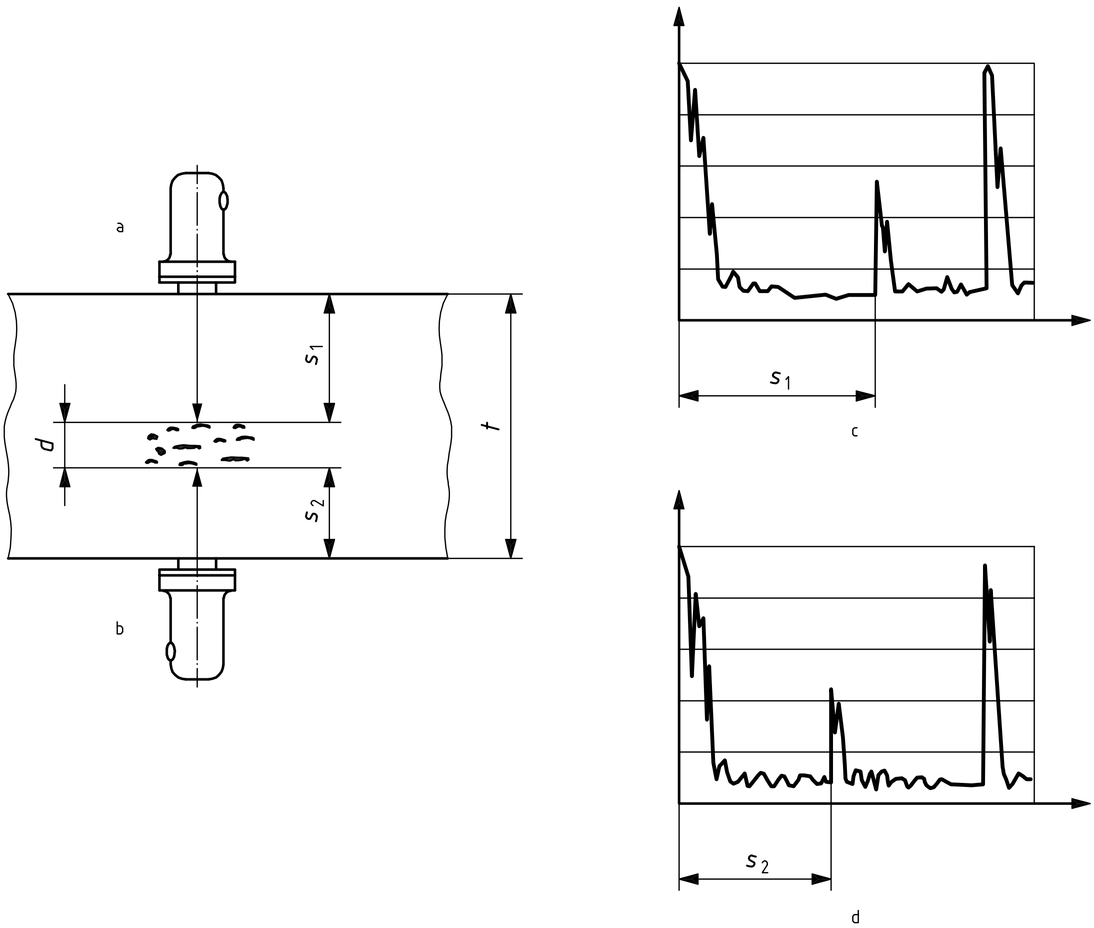
t Thickness

α Angle of incidence

Y Echo height

$d = (s_2 - s_1) \times \cos \alpha$

Figure 3 — Measurement of the dimension of discontinuities in the through-wall direction



Key

a Scanning position “A”.

b Scanning position “B”.

c A-scan from scanning position “A”.

d A-scan from scanning position “B”.

Depth extension $d = t - (s_1 + s_2)$

where

t is the wall thickness;

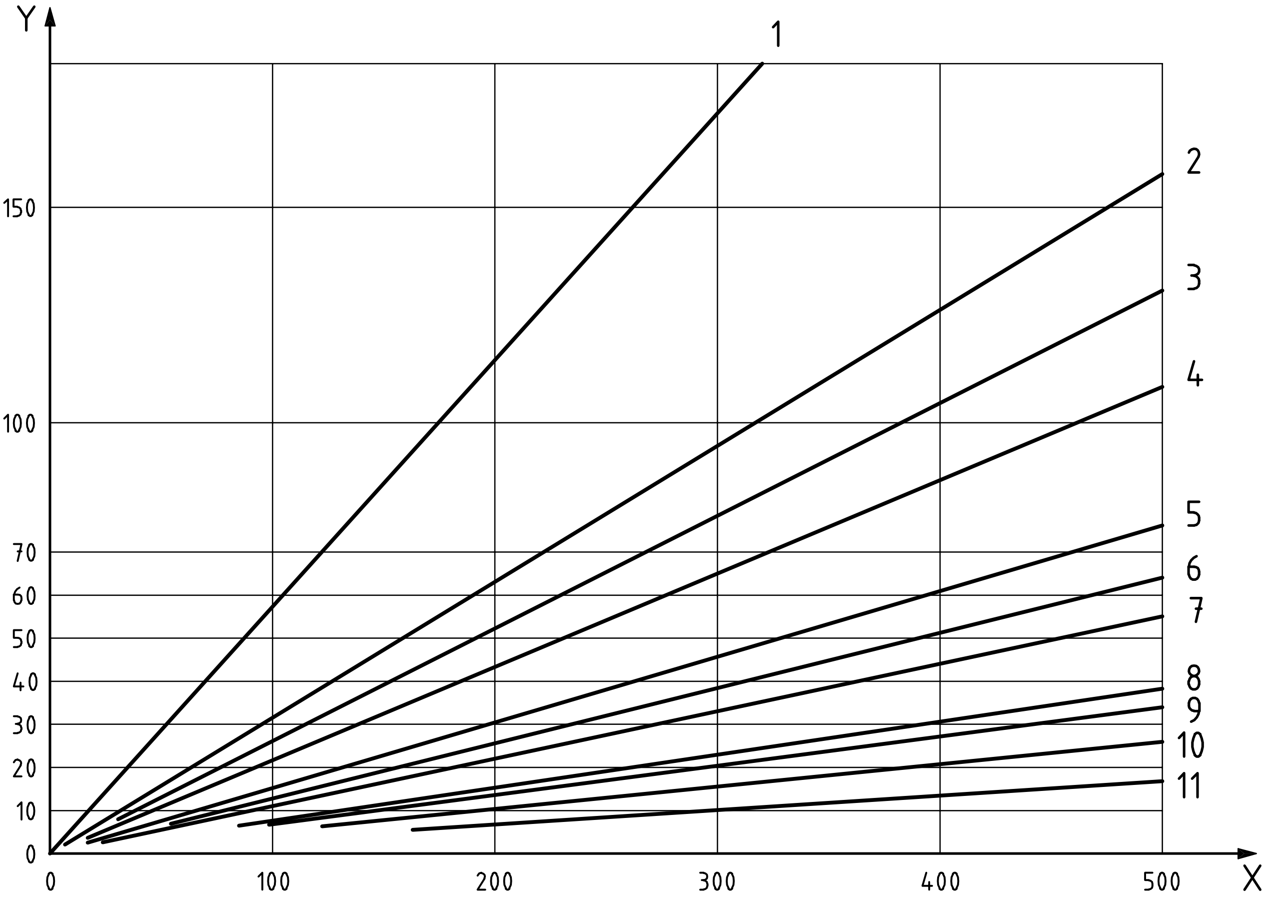
s_1, s_2 are the lengths of the sound-beam paths.

Figure 4 — Measurement of the dimension of discontinuities in the through-wall direction with normal probes

Annex A
(informative)

Sound-beam diameters

This annex gives information on sound-beam diameters in order to distinguish between discontinuities with or without measurable dimensions.



Near-field lengths

Probe crystal dimension	Near-field length in millimetres (approximate values)					
	longitudinal waves (L)				transverse waves (T)	
mm	1 MHz	2 MHz	4 MHz	5 MHz	2 MHz	4 MHz
∅ 10	4,2	8,0	15,6	—	—	—
∅ 24	22,7	45	88	115	—	—
8 × 9	—	—	—	—	14	28
20 × 22	—	—	—	—	75	150

Key

1 1 MHz, L, ∅ 10
2 2 MHz, L, ∅ 10
3 1 MHz, L, ∅ 24
4 2 MHz, T, 8 × 9
5 4 MHz, L, ∅ 10
6 2 MHz, L, ∅ 24
7 4 MHz, T, 8 × 9
8 2 MHz, T, 8 × 9
9 4 MHz, L, ∅ 24
10 5 MHz, L, ∅ 24
11 4 MHz, T, 20 × 22

X Sound-beam path, in millimetres
Y Sound-beam diameter (– 6 dB), in millimetres

Figure A.1 — Sound-beam diameters according to sound-beam path and near-field length for various probes

The near-field length and the sound-beam diameter can be calculated using the following formulae:

$$N = \frac{D_c^2}{4 \times \lambda} \tag{A.1}$$

$$D_F = \frac{2 \times s}{D_c} \tag{A.2}$$

where

N is the near-field length, in millimetres;

D_c is the crystal diameter, in millimetres;

λ is the wave length, in millimetres;

s is the sound-beam path in millimetres;

D_F is the sound-beam diameter, in millimetres, along the sound-beam path, where the decrease of the sound pressure perpendicular to the central beam is 6 dB.

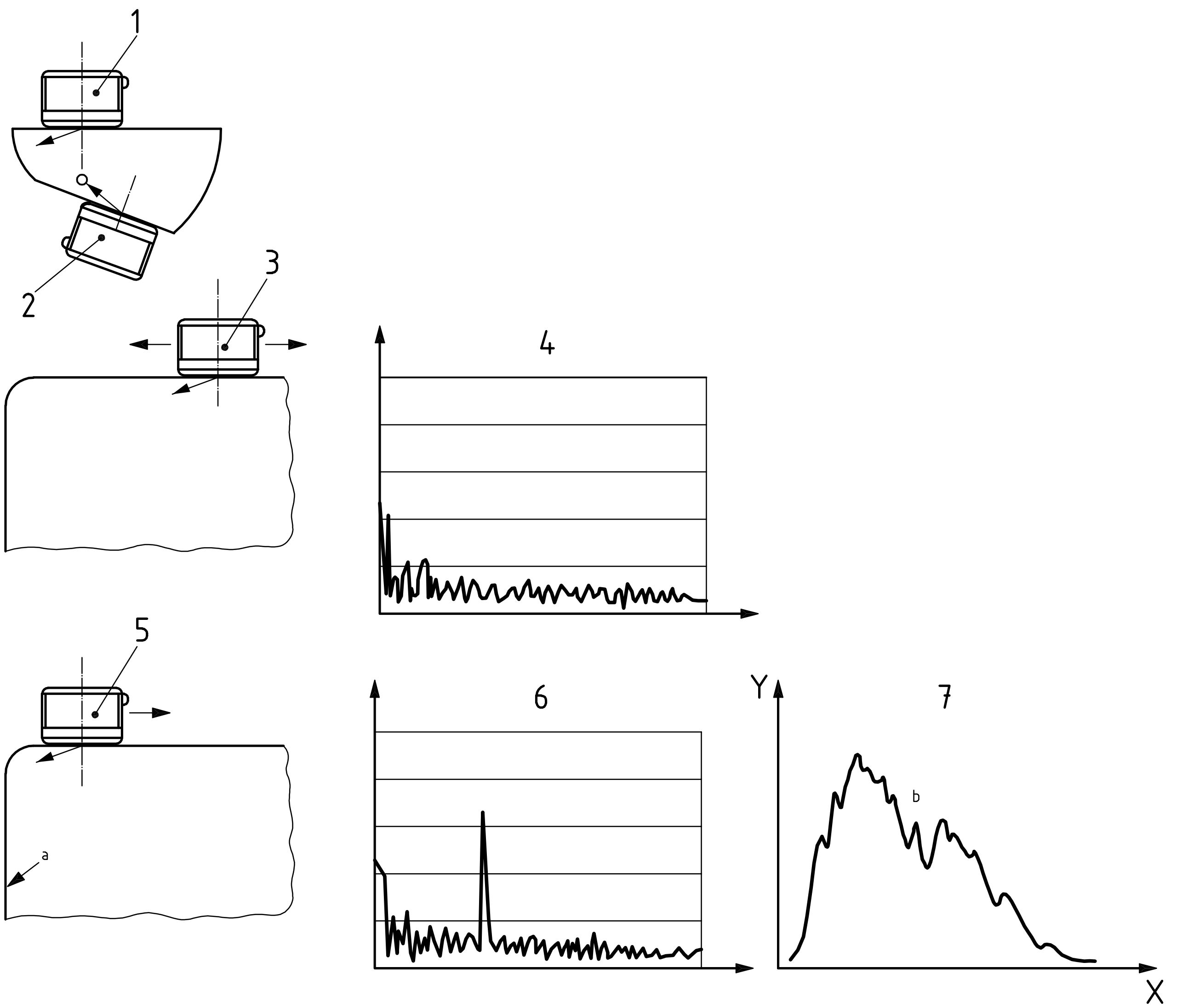
Annex B
(informative)

Types of indications

Figures B.1 to B.11 show possible distinctions between the different types of indications by echo-dynamics.

For the identification of the type of indication, the test sensitivities can be changed according to:

- the distance from the surface to be examined;
- the geometrical shape;
- the surface finish of the surface to be examined.



Key

1 Range setting, e.g. with calibration block in accordance with EN 12223 or ISO 7963

2 Check of test equipment on side-drilled hole of calibration block, echo height of side-drilled hole is 100 % of screen height

3 Sensitivity setting in an area of the casting to be examined, free from discontinuities without reference reflector

4 Average height of noise level approximately 5 % to 10 % of screen height

5 Check of test sensitivity and test equipment by observation of the echo-dynamics of an as-cast surface in the through-wall direction

6 A-scan

7 Typical echo dynamic

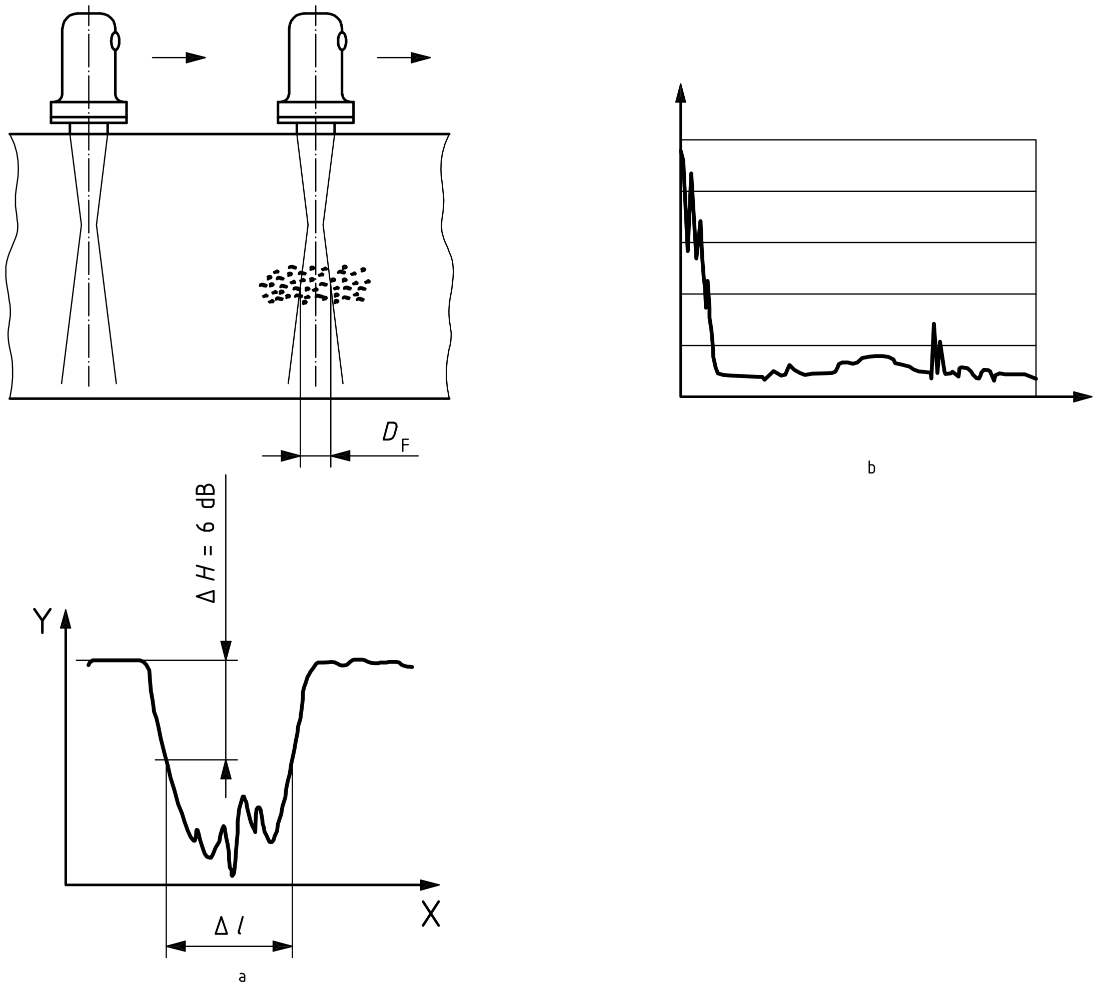
X Probe movement

Y Echo height

[a] As-cast surface.

[b] Echo dynamics.

Figure B.1 — Range setting and sensitivity setting of ultrasonic instrument with a twin- crystal angle probe scan (4 MHz, 60° angle) to detect discontinuities mainly orientated in the through-wall direction with a measurable dimension in the region of the rim zone



Typical indication:

Reduction of backwall echo by more than 12 dB. Indications from discontinuities that are frequently invisible.

Reason: spongy shrinkage, gas holes, inclusions or large inclined discontinuity.

$\Delta l > D_F$

where

D_F is the sound-beam diameter;

Δl is the dimension of the discontinuity.

Key

ΔH Reduction of backwall echo

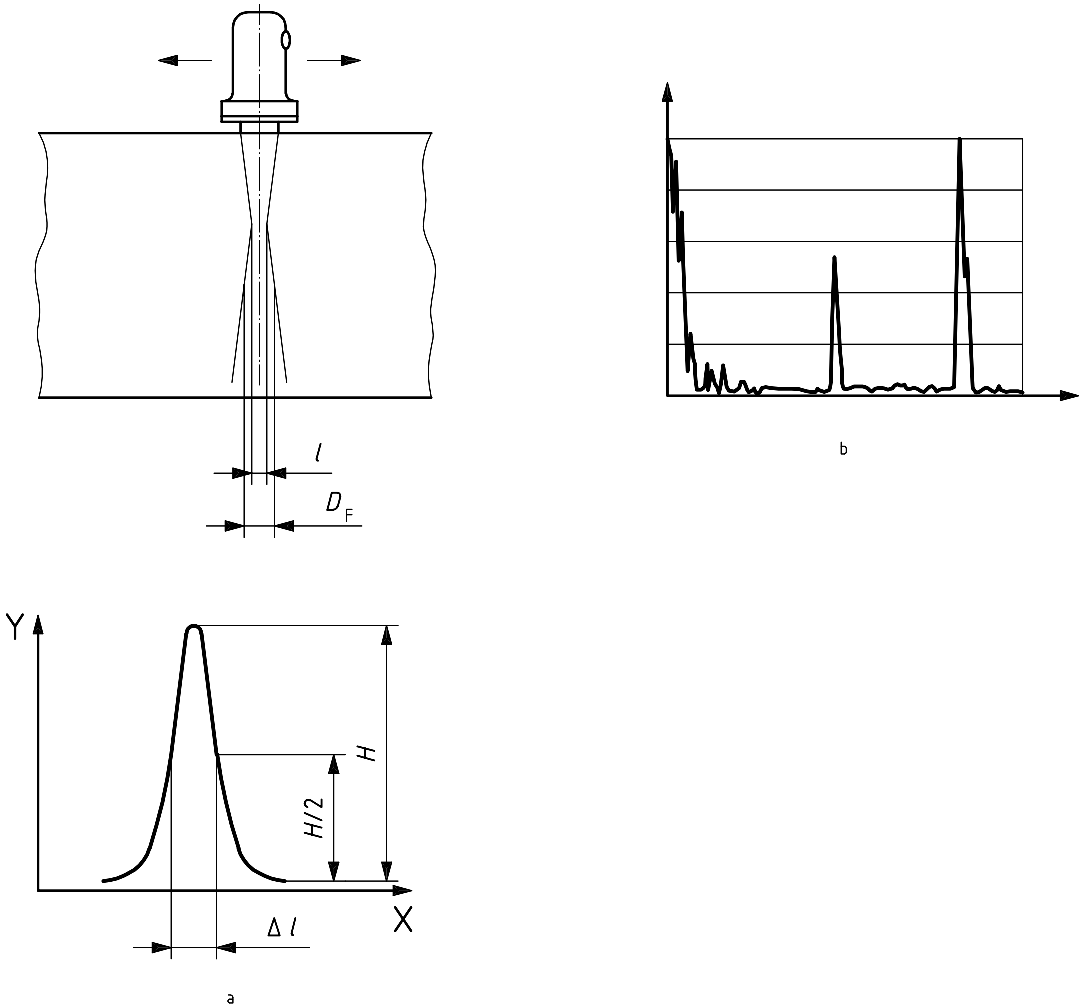
X Probe movement

Y Echo height

[a] Echo dynamics.

[b] A-scan.

Figure B.2 — Reduction of backwall echo by more than 12 dB, measurable dimension of indication range



Typical indication:

Individual indication, half-value dimension Δl smaller than or equal to the sound-beam diameter D_F.

Key

l Lateral extension of indication

H Maximum echo height of individual indication

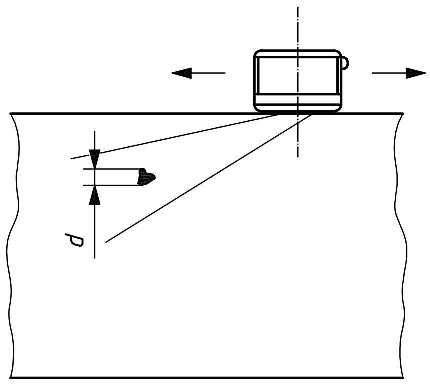
X Probe movement

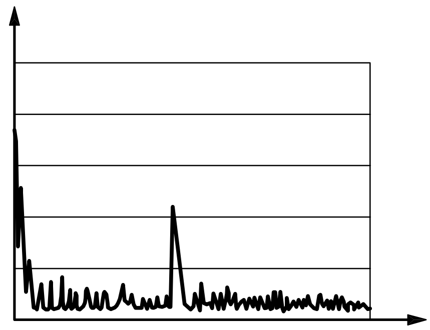
Y Echo height

a Echo dynamics.

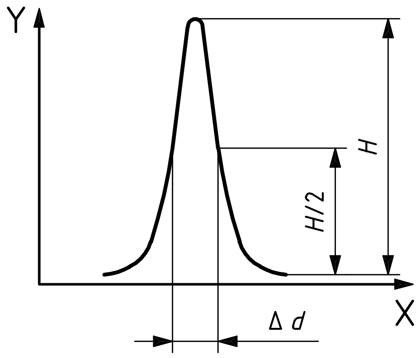
b A-scan.

Figure B.3 — Individual indication without measurable dimensions





b



a

Typical indication:

Individual indication, half-value dimension Δd equal to or less than sound-beam diameter D_F at reflection point.

Key

d Dimension of indication in the through-wall direction

H Maximum echo height of individual indication

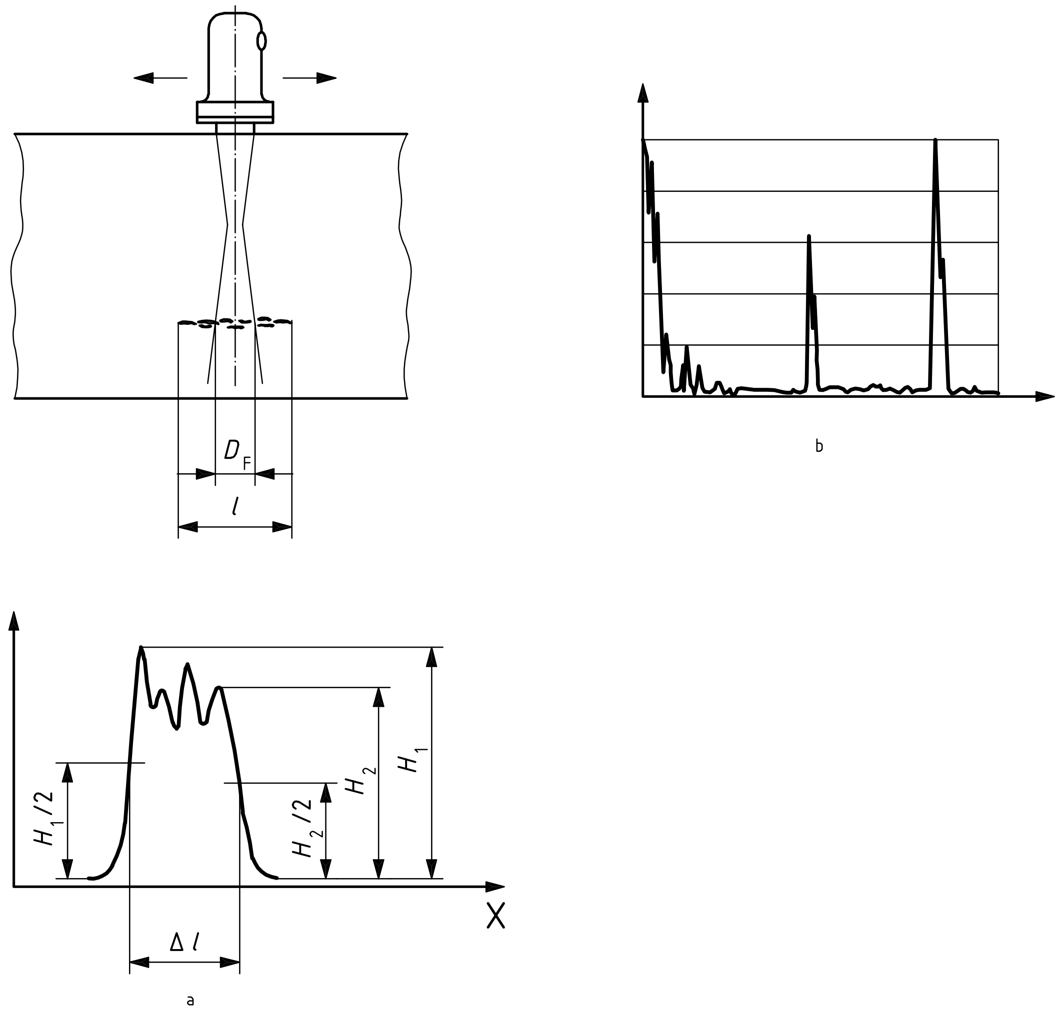
X Probe movement

Y Echo height

[a] Echo dynamics.

[b] A-scan.

Figure B.4 — Individual indication without measurable dimensions; individual indication with one measurable dimension parallel to the test surface and without a measurable dimension in the through-wall direction



Typical indication:

Individual indication(s), mainly in the same position in the through-wall direction.

Dimension of indication range larger than the sound-beam diameter D_F.

Key

l Lateral extension of indication

Δl Half-value dimension of indication

H_1, H_2 Last maximum echo heights on opposite sides of indication

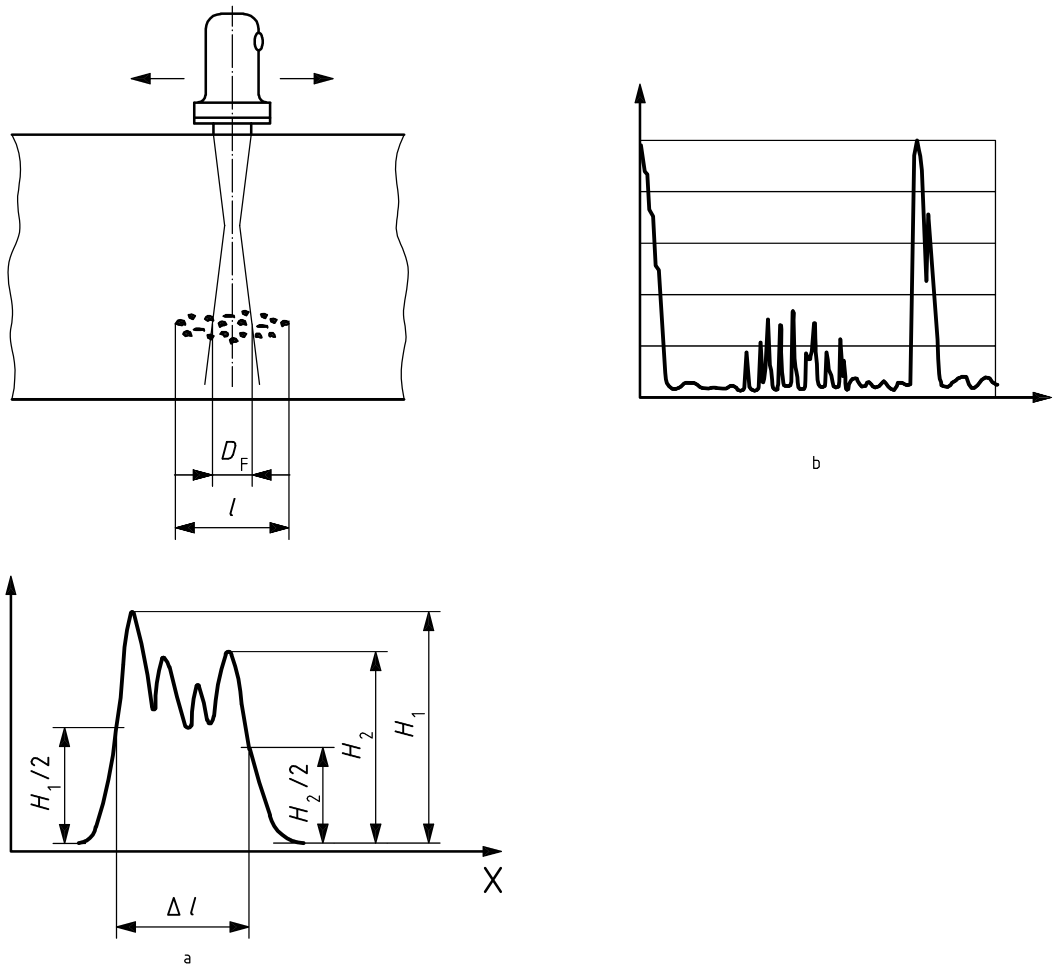
X Probe movement

Y Echo height

[a] Echo dynamics.

[b] A-scan.

Figure B.5 — Individual indication with measurable dimensions: measurable length, non-measurable width; measurable length, measurable width



Typical indication:

Clustering of indications, mainly resolvable with non-measurable dimensions.

Dimension of indication range equal to or larger than the sound-beam diameter D_F.

Key

l Lateral extension of indication

Δl Half-value dimension of indication

H_1, H_2 Last maximum echo heights on opposite sides of indication

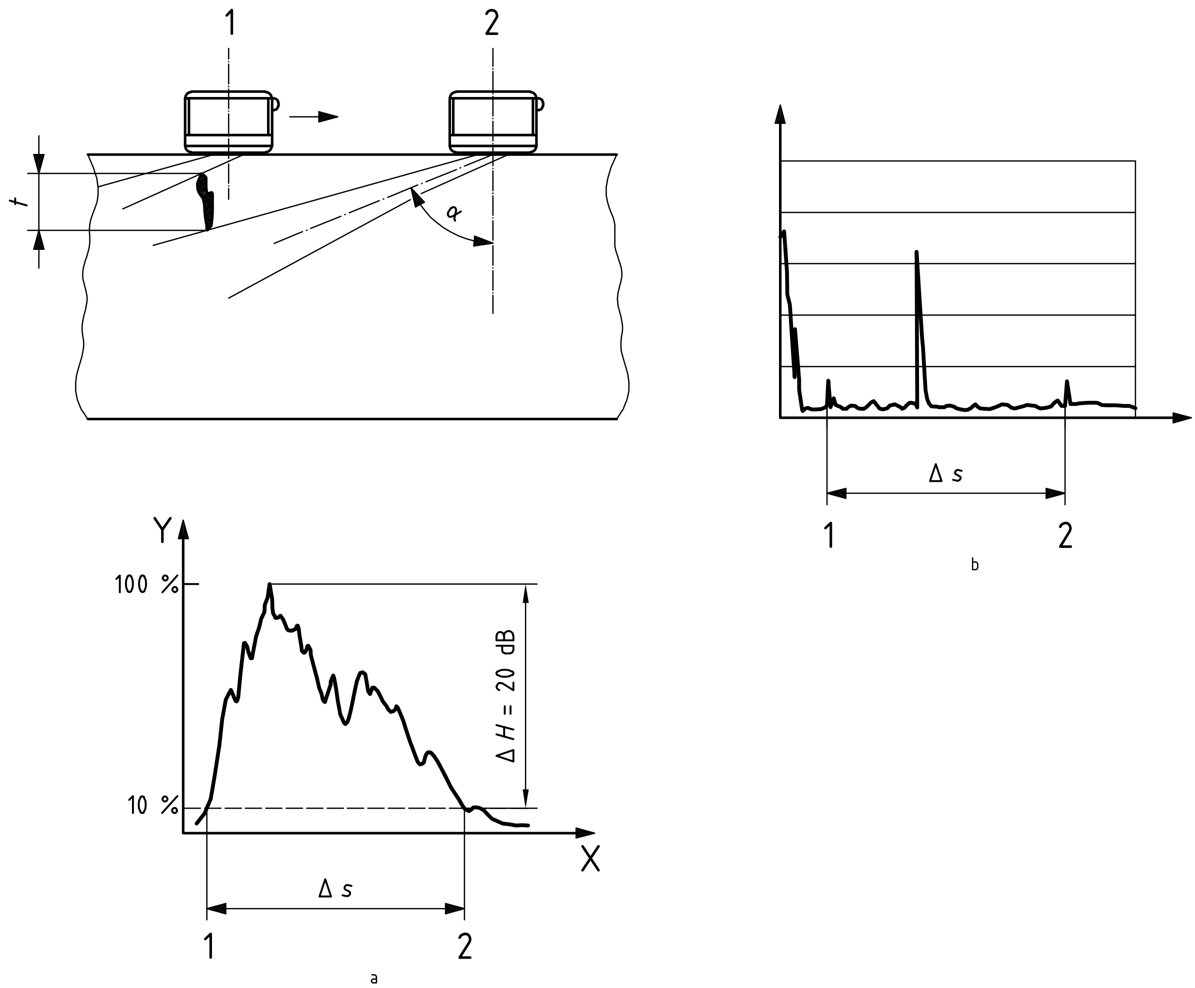
X Probe movement

Y Echo height

[a] Echo dynamics.

[b] A-scan.

Figure B.6 — Group of resolvable indications with measurable dimensions of the indication range



Typical indication:

Individual echo with pronounced echo dynamics only in the through-wall direction (travelling indication), or both in the through-wall direction and parallel to the test surface:

$t = \Delta s \times \cos \alpha$

where

t is the dimension in the through-wall direction;

Δs is the difference of sound paths from position 2 to position 1;

α is the angle of incidence.

Key

1 Probe position 1

2 Probe position 2

ΔH Reduction of maximum echo height of indication

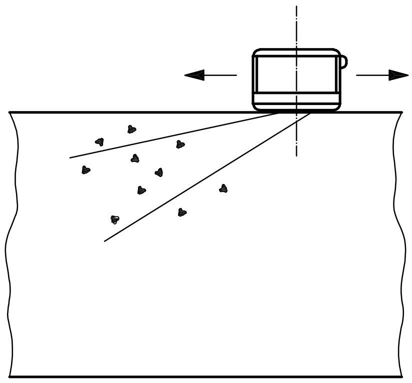
X Probe movement

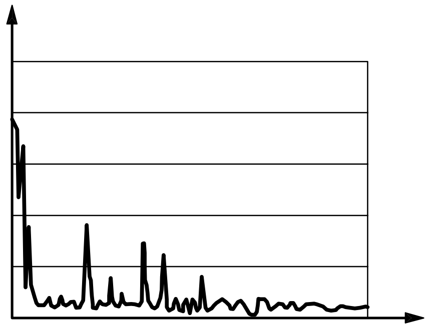
Y Echo height

a Echo dynamics.

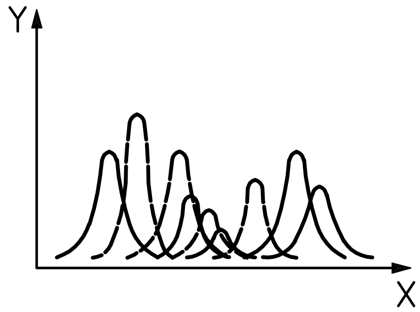
b A-scan.

Figure B.7 — Individual indication with measurable dimensions in the through-wall direction





b



a

Typical indication:

Numerous individual indications.

During probe movement the sound paths change, but all indications remain without measurable dimensions.

Key

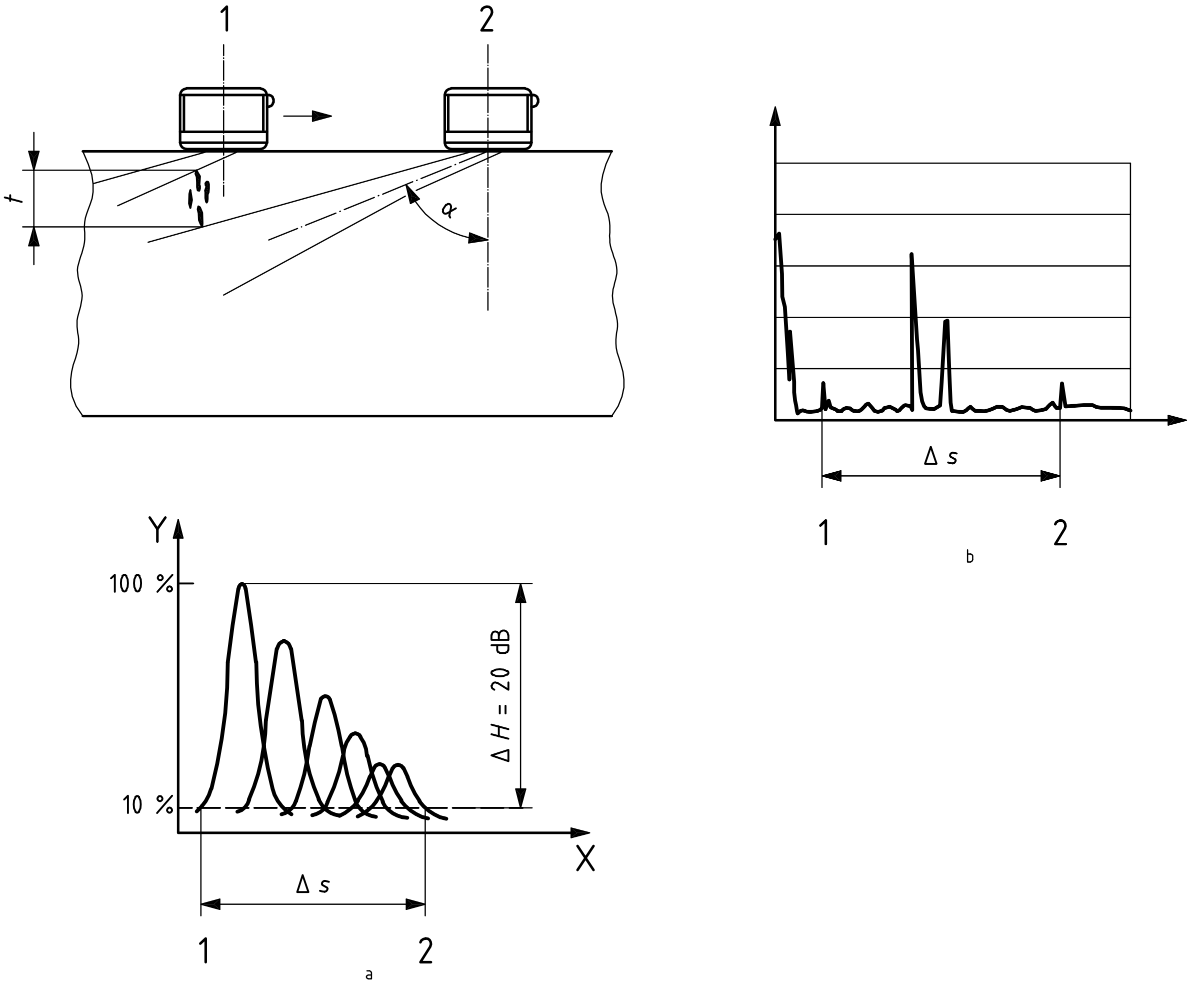
X Probe movement

Y Echo height

a Echo dynamics.

b A-scan.

Figure B.8 — Numerous individual indications without measurable dimensions but with measurable dimensions of the indication range



Typical indication:

Individual indications with measurable dimensions mainly in the through-wall direction:

$t = \Delta s \times \cos \alpha$

where

t is the dimension of the indication range in the through-wall direction;

Δs is the difference of sound paths from position 2 and position 1;

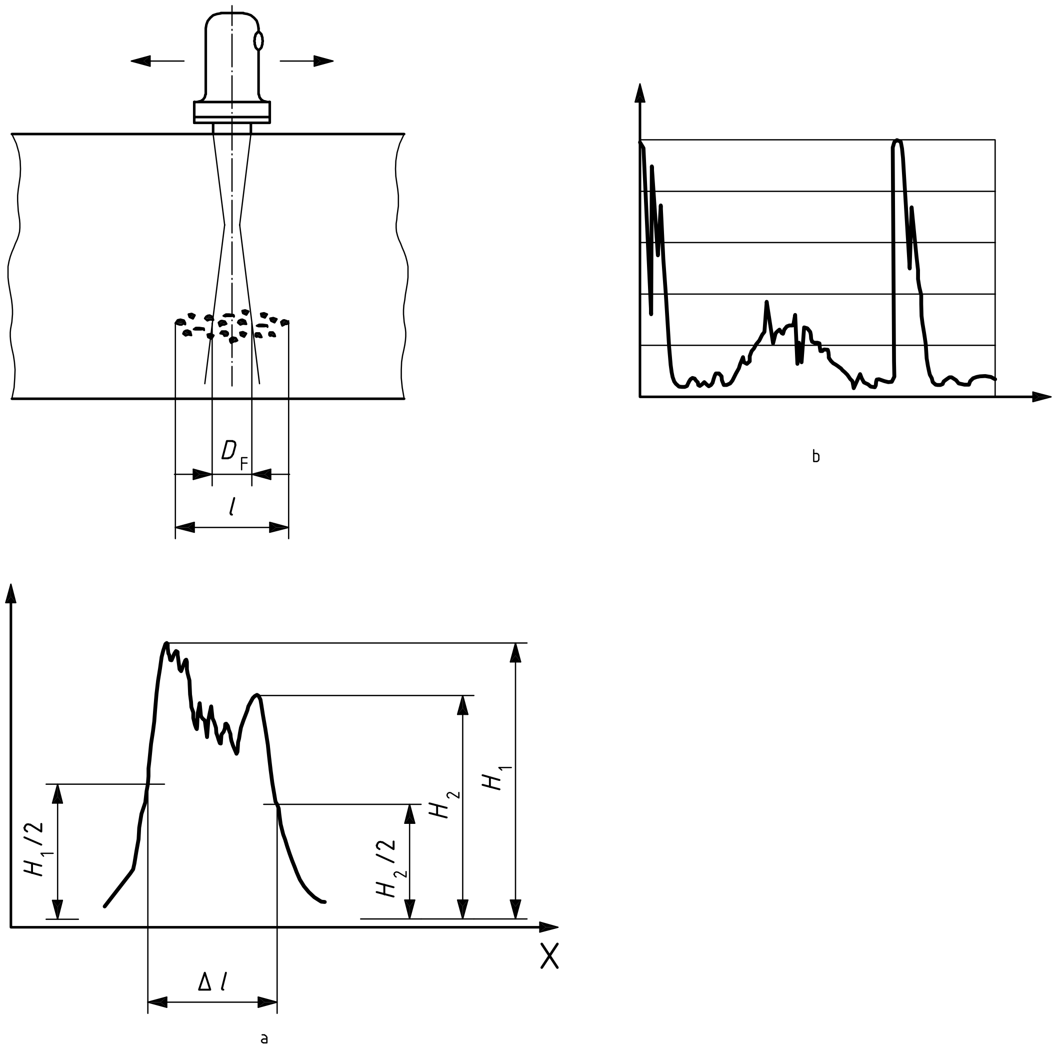
α is the angle of incidence.

Key

1 Probe position 1
2 Probe position 2
ΔH Reduction of maximum echo height of indication
X Probe movement
Y Echo height

a Echo dynamics.
b A-scan.

Figure B.9 — Numerous planar indications with measurable dimensions in the through-wall direction



Typical indication:

Group of indications, mainly non-resolvable individual indication. Dimension of indication range equal to or larger than sound-beam diameter D_F.

This type of indication should only be evaluated if, due to geometrical reasons, a backwall echo cannot be obtained.

A simultaneous reduction of backwall echo should be evaluated in accordance with Figure B.2.

Key

l Lateral extension of indication

Δl Half-value dimension of indication

D_F Sound-beam diameter

H_1, H_2 Last maximum echo heights on opposite sides of indication

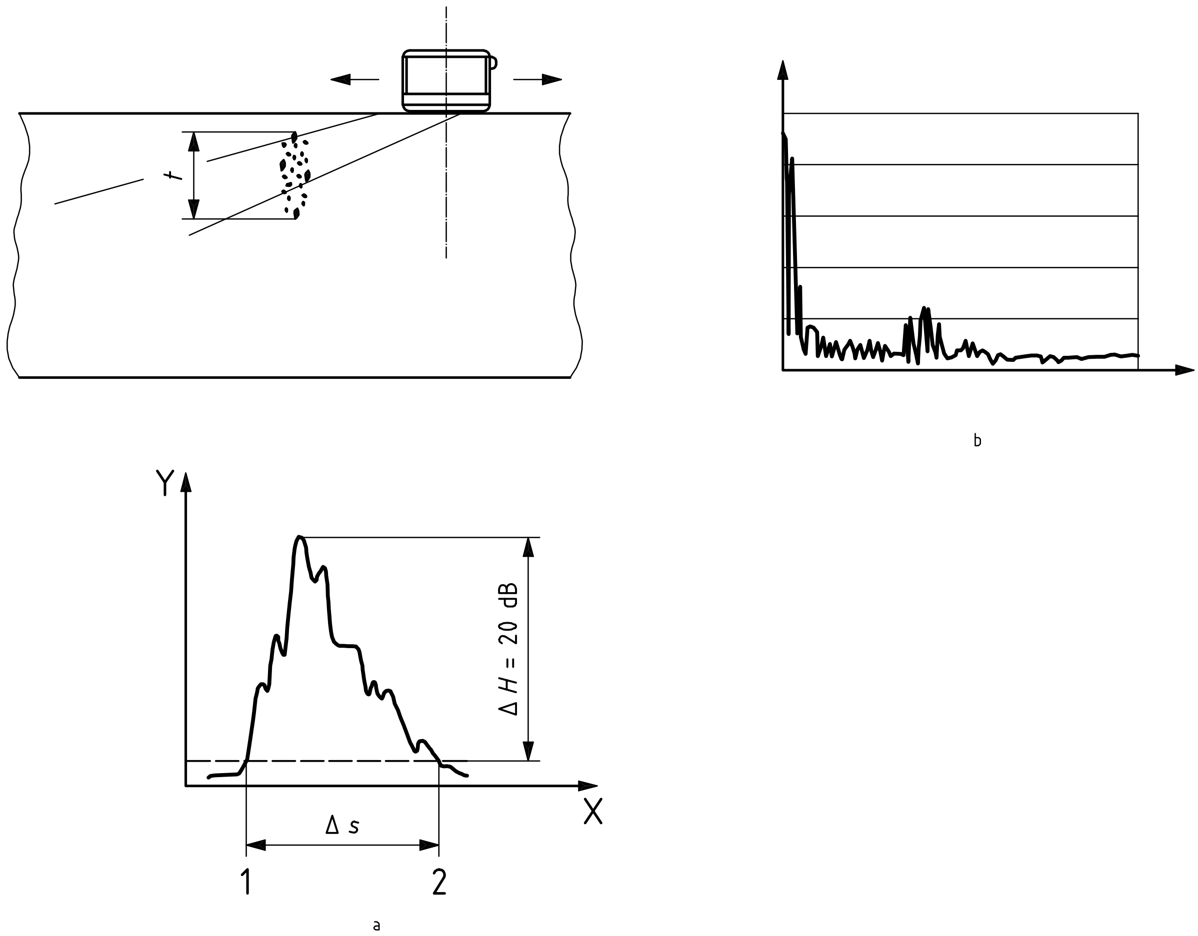
X Probe movement

Y Echo height

a Echo dynamics.

b A-scan.

Figure B.10 — Group of non-resolvable indications with measurable dimensions of indication range (normal probe)



Typical indication:

Group of mainly non-resolvable indications:

$t = \Delta s \times \cos \alpha$

where

t is the dimension of the indication range in the through-wall direction;

Δs is the difference of sound paths from position 2 and position 1;

α is the angle of incidence.

Key

1 Probe position 1
2 Probe position 2
ΔH Reduction of maximum echo height of indication
X Probe movement
Y Echo height

[a] Echo dynamics.

[b] A-scan.

Figure B.11 — Group of non-resolvable indications with measurable dimensions of indication range (angle probe)

Bibliography

[1] ISO 9712, *Non-destructive testing — Qualification and certification of personnel*

[2] EN 473, *Non destructive testing — Qualification and certification of NDT personnel — General principles*

[3] EN 1370, *Founding — Surface roughness inspection by visualtactile comparators*

[4] EN 1559-2, *Founding — Technical conditions of delivery — Part 2: Additional requirements for steel castings*

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