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

*Pièces moulées en acier - Contrôle par ultrasons —*

*Partie 2: Pièces moulées en acier pour composants fortement sollicités*

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

This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 11, *Steel castings*.

This second edition cancels and replaces the first edition (ISO 4992-2:2006), which has been technically revised. The main changes compared to the previous edition are as follows:

- New definition added for “rim zone” (3.6) and “non-measurable dimension (3.8);
- New subclause 4.3.3.1;
- Figure 1 was redrawn;
- Text in Figure 2 moved to 4.3.3.2 and text in Figures 3 and 4 moved to 4.3.3.3;
- Figure referenced in 5.5.3.3 was corrected (new Figure 5 added);
- Figure 5 was renumbered as Figure 6;
- Subtitles added to Figure 1, Figure 6, and Figures in Annex C;
- Figure B.1 Key 8 was corrected;
- Table in Figure B.1 numbered as Table B.1.

A list of all parts in the ISO 4992 series can be found on the ISO website.

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

# Steel castings — Ultrasonic testing —

## Part 2:

## Steel castings for highly stressed components

### 1 Scope

This document specifies the requirements for the ultrasonic testing of steel castings (with ferritic structure) for highly stressed components, and the methods for determining internal discontinuities by the pulse-echo technique. Purchasers determine if components are highly stressed based on the need for performance or safety.

This document applies to the ultrasonic testing 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 the acceptance levels.

This document does not apply to austenitic steels and to joint welds.

### 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 2400, *Non-destructive testing — Ultrasonic testing — Specification for calibration block No. 1*

ISO 5577, *Non-destructive testing — Ultrasonic testing — Vocabulary*

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

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO 11971, *Steel and iron castings — Visual testing of surface quality*

ISO 16810, *Non-destructive testing — Ultrasonic testing — General principles*

ISO 16811, *Non-destructive testing — Ultrasonic testing — Sensitivity and range setting*

ISO 16827-2012, *Non-destructive testing — Ultrasonic testing — Characterization and sizing of discontinuities*

ISO 22232-1<sup>1)</sup>, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 1: Instruments*

ISO 22232-2<sup>2)</sup>, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 2: Probes*

ISO 22232-3<sup>3)</sup>, *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 3: Combined equipment*

1) Under preparation. Stage at the time of publication: ISO/DIS 22322-1.

2) Under preparation. Stage at the time of publication: ISO/DIS 22322-2.

3) Under preparation. Stage at the time of publication: ISO/DIS 22322-3.

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577, ISO 16810, ISO 16811, ISO 16827 and the following 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**  
**equivalent reference discontinuity echo size**  
indication to be recorded during the assessment phase of an ultrasonic test, usually expressed as an equivalent diameter of a flat-bottomed hole (FBH)

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

Note 1 to entry: Dimensions in this document relate to length, width and/or dimension in the through-wall direction.

**3.3**  
**extended discontinuity**  
discontinuity, the dimensions of which are larger than the sound-beam diameter

Note 1 to entry: Dimensions in this document 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**  
**rim zone**  
1/3 the through-wall thickness from the surface with a maximum of 30 mm

**3.7**  
**special rim zone**  
outer *rim zone* (3.6) of the test object with special requirements

Note 1 to entry: Examples of special requirements are machined surfaces, higher stresses and sealing surfaces.

**3.8**  
**non-measurable discontinuity**  
dimension of the discontinuity that cannot be determined, non-measurable, by scanning (dB-drop) when the dimension is smaller than the beam width, which depends on the probe size and the frequency used

Note 1 to entry: Current state of the industry is <3 mm.

**3.9**  
**production welding**  
any welding on the test object carried out during manufacturing before final delivery to the purchaser

**3.10**  
**joint welding**  
production welding used to assemble components together to obtain an integral unit

**3.11****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 ISO 16810):

- a) the areas of the casting and the number or percentage of castings to which the requirements of ultrasonic testing apply;
- b) the acceptance levels to be applied to the various zones or areas of the casting;
- c) requirements for a written test procedure;
- d) whether there are any additional requirements for the test procedure, see also [5.5.1](#).

**4.2 Extent of testing**

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

For wall thicknesses greater than 600 mm, agreement shall be made between the purchaser and manufacturer on the acceptance levels, test procedure, and the recording of the test results.

**4.3 Maximum acceptable size of discontinuities****4.3.1 General**

The purchaser shall specify the acceptance level according to the required class for planar and volumetric discontinuities within each zone and in each specified area of the casting.

The wall section shall be divided into core and rim zones as shown in [Figure 1](#). These sections relate to the sizes of castings ready for assembly (finish-machined).

**4.3.2 Indications without measurable dimensions**

In special rim zones and at weld preparation ends, indications without measurable dimensions are limited to a maximum number of indications.

These indications shall not exceed the limits given in [Table 1](#).

**4.3.3 Indications with measurable dimensions****4.3.3.1 General**

Single discontinuities extending into the rim zone and core zone shall be evaluated as rim zone.

**4.3.3.2 Planar discontinuities**

Planar discontinuities shall not exceed the limits given in [Figure 2](#).

Discontinuities exceeding 3 mm FBH shall not be acceptable in class 1.

The largest dimension of a discontinuity in the through-wall direction shall not exceed 10 % of the wall thickness, except discontinuities with a length  $\leq 10$  mm. Discontinuities with a length  $\leq 10$  mm shall not exceed a dimension in the through-wall direction of 25 % of the wall thickness.

The greatest distance between discontinuities, as criterion for evaluation as an individual discontinuity or a discontinuity area in the through-wall direction or lateral to the surface, shall be 10 mm.

For a discontinuity with more than 3 mm in 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:

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

where

$A$  is the area of discontinuity, in square millimetres;

$3$  is the width taken, in millimetres;

$L$  is the length, in millimetres.

The sizing of small planar discontinuities, as given in [Figure 2](#), becomes more difficult with increasing beam-path length and sound-beam diameter. As a guide, these sizings are normally applied to a rim zone of 30 mm. This makes the use of probes with focused beams, such as dual-transducer probes, necessary.

#### 4.3.3.3 Volumetric discontinuities

Volumetric discontinuities shall not exceed the sizes given in [Figure 3](#) for the rim zone and [Figure 4](#) for the core zone.

Indications exceeding 3 mm FBH shall not be acceptable as class 1.

The maximum acceptable dimensions of discontinuity areas in the through-wall direction in the rim zone shall be 15 % of the rim zone thickness. The maximum acceptable dimensions of discontinuity areas in the through-wall direction in the core zone shall be 15 % of the wall thickness.

The maximum distance between discontinuities, as a criterion for evaluation as an individual indication in the through-wall direction or lateral to the surface, shall be 10 mm in the rim zone and 20 mm in the core zone.

For a discontinuity with more than 3 mm in 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:

$$A = 3L \quad (2)$$

where

$A$  is the area of discontinuity, in square millimetres;

$3$  is the width taken, in millimetres;

$L$  is the length, in millimetres.

Unless otherwise agreed at the time of enquiry and order, when conducting radiographic and ultrasonic testing in combination it was proven that if a discontinuity indicated by radiographic testing is situated in the core zone, the discontinuity is acceptable at one level lower, e.g. in class 3 instead of class 2 for radiographic testing. For further information, see EN 1559-2.

#### 4.4 Qualification of personnel

Ultrasonic testing shall be performed by qualified personnel. Qualification of personnel may be according to ISO 9712 or other equivalent recognised standards.

#### 4.5 Wall-section zones

The wall section shall be divided into core and rim zones as shown in [Figure 1](#). These sections relate to the dimensions of the casting ready for assembly (finish-machined).

#### 4.6 Classes

If the purchaser specifies different classes in different areas of the same casting, all of these areas shall be clearly identified and shall include:

- a) all necessary dimensions for accurate location of zones;
- b) the full extent of all weld preparations and the thickness of any special rim zone.

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

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

### 5 Testing

#### 5.1 Principles

The principles of ultrasonic testing given in ISO 16810, ISO 16811 and ISO 16827 shall apply.

#### 5.2 Material

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

The reference echo height according to [Table 2](#) shall be at least 6 dB above the noise level.

If the echo height of the smallest detectable flat-bottomed or equivalent side-drilled hole diameter at the far end of the test range to be assessed is less than 6 dB above the noise level, then the ultrasonic testing has reduced performance. In this case, the diameter of the flat-bottomed or side-drilled hole which can be detected with a signal-to-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 diameter of a flat-bottomed hole, 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 can be used for converting a flat-bottomed hole diameter into an equivalent side-drilled hole diameter:

$$D_{SDH} = \frac{4,935 D_{FBH}^4}{\lambda^2 s} \quad (3)$$

where

- $D_{SDH}$  is the side-drilled hole diameter, in millimetres;  
 $D_{FBH}$  is the flat-bottomed hole diameter, in millimetres;  
 $\lambda$  is the wavelength, in millimetres;  
 $s$  is the path length, in millimetres.

Formula (3) is applicable for  $D_{SDH} \geq 2\lambda$  and  $s \geq 5$  times the near-field length and is only defined for single-element probes.

### 5.3 Test equipment, coupling fluid, test sensitivity and resolution of detection

#### 5.3.1 Ultrasonic instrument

The ultrasonic instrument shall meet the requirements given in ISO 22232-1 and shall have the following characteristics:

- a) range setting capability, from at least 10 mm to 2 m continuously selectable, for longitudinal and transverse waves transmitted in steel;
- b) gain span, adjustable in 2 dB maximum steps over a range of at least 80 dB with an accuracy of 1 dB;
- c) time-base and vertical linearities less than 5 % of the adjustment range of the screen;
- d) suitability, at least for nominal frequencies from 1 MHz up to and including 6 MHz, in the pulse-echo technique with single-transducer and dual-transducer probes.

#### 5.3.2 Probes and transducer frequencies

The probes and transducer frequencies shall be as given in ISO 22232-2, ISO 22232-2 and ISO 22232-3 with the following exceptions:

- a) nominal frequencies shall be in the range 1 MHz to 6 MHz;
- b) for oblique incidence, angle-beam probes with angles between 35° and 70° shall be used.

NOTE Normal-beam or angle-beam probes can be used for the testing of steel castings for highly stressed components. The type of probe used depends on the geometry of the casting and the type of discontinuity to be detected.

For test zones close to the surface, dual-element probes (normal-beam or angle-beam) should be preferred.

#### 5.3.3 Checking of the ultrasonic test equipment

The ultrasonic test equipment shall be checked regularly by the operator in accordance with ISO 22232-3.

#### 5.3.4 Coupling fluid

A coupling fluid in accordance with ISO 16810 shall be used. The coupling fluid shall wet the test surface to ensure satisfactory sound transmission. The same coupling fluid shall be used for the calibration and all subsequent test operations.

NOTE The sound transmission can be checked by one or more stable back-wall echoes in areas with parallel surfaces.

### 5.3.5 Test sensitivity and resolution of detection

The test sensitivity of the instrument shall allow at least the setting of the sensitivity in accordance with the requirements of [5.5.2](#).

The resolution of detection of the instrument-probe combination shall meet the requirements of [Annex A](#).

## 5.4 Preparation of casting surfaces for testing

For the preparation of casting surfaces for ultrasonic testing, see ISO 16810.

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

With single-element probes, satisfactory coupling can be achieved if the surfaces correspond at least to the limit comparator 4 S1 or 4 S2 according to ISO 11971.

The roughness of any machined surface used for testing shall be  $R_a \leq 12,5 \mu\text{m}$ .

For special test techniques, higher surface qualities such as 2 S1 or 2 S2 (see ISO 11971) and  $R_a \leq 6,3 \mu\text{m}$  may be necessary.

## 5.5 Test 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 discontinuities in the casting or on the possible discontinuities from finishing welding, the applicable test procedure shall be specified by the manufacturer of the casting.

If possible, the areas to be tested shall be tested 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 dual-element 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, dual-element normal-beam and/or angle-beam probes shall be used to test the following areas up to a depth of 50 mm:

- a) critical areas, e.g. fillets, changes in cross-section, areas with external chills;
- b) finishing welds;
- c) weld preparation areas, as specified in the order;
- d) 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 testing with other suitable angle-beam probes.

For angle-beam probes with angles over  $60^\circ$ , the sound path shall not exceed 150 mm.

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

The scanning speed shall not exceed 150 mm/s.

### 5.5.2 Range setting

Range setting on the ultrasonic instrument shall be carried out in accordance with ISO 16811, using normal-beam or angle-beam probes in accordance with one of the three options given below:

- a) with the calibration block No. 1 in accordance with ISO 2400, or block No. 2 in accordance with ISO 7963;
- b) with an alternative calibration block made in a material exhibiting similar acoustic properties to those of the material to be tested;
- c) on the casting itself when using normal-beam probes. The casting to be tested shall have parallel surfaces, the distance between which shall be measured and recorded.

### 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 ISO 16811. One of the following two techniques shall be used:

- a) Distance-amplitude correction curve technique (DAC)

The distance-amplitude 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 path.

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

- b) Distance-gain-size technique (DGS)

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

#### 5.5.3.2 Transfer correction

Transfer correction shall be determined in accordance with ISO 16811.

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 back-wall 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 ISO 11971, this surface has a quality which is sufficient for transfer correction measurements.

#### 5.5.3.3 Detection of discontinuities

For the detection of discontinuities, 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 full screen height (FSH) at the end of the thickness range to be tested.

If, during testing, suspicion arises that the reduction of back-wall echo signal exceeds the recordable value (see Table 3), testing shall be repeated using locally reduced test sensitivity and the reduction of back-wall echo signal 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 5) 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 compared to the width of the sound beam.

Under these circumstances, the probe shoe should be contoured to fit to the contour of the casting (see ISO 16811).

#### 5.5.4 Consideration of various types of indications

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

- a) reductions of back-wall echo which is not due to the shape of the casting or the coupling;
- b) echoes from discontinuities.

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

#### 5.5.5 Recording and recording limits

##### 5.5.5.1 Reduction of back-wall echo

All back-wall echo reductions in excess of 12 dB (for a nominal test frequency of 2 MHz) shall be recorded. The back-wall echo reductions to be recorded shall be marked on the test object and measured as indication areas.

##### 5.5.5.2 Echo indications from discontinuities

The recording level of an echo indication is defined by its signal amplitude according to the signal from a reference discontinuity.

All echo indications from discontinuities with measurable dimensions shall be recorded, when the signal amplitude exceeds both the levels given in [Table 3](#) and the criteria given in [Figures 3](#) and [4](#).

Distinction shall be made between the different types of indications given in [Table 4](#).

To identify the type of indication, the test sensitivity can be changed according to the distance from the test surface, the geometrical shape and the surface finish of the test surface.

When using transverse wave probes, irrespective of their 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 [5.5.7.3](#).

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

#### 5.5.6 Assessment 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 assessment can be achieved by altering the ultrasonic test technique (e.g. changing the angle of incidence) or by additionally carrying out radiographic testing.

## 5.5.7 Characterization and sizing of discontinuities

### 5.5.7.1 General

For characterization and sizing of discontinuities, see ISO 16827.

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 discontinuity type, 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 characterizations of discontinuities can be made:

- a) discontinuities without measurable dimensions (point-like discontinuities);
- b) discontinuities with measurable dimensions (extended discontinuities).

NOTE 1 [Annex B](#) gives information on sound-beam diameters in order to distinguish between discontinuities with or without measurable dimensions.

NOTE 2 [Annex C](#) gives information on types of discontinuities 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 to use probes with a sound-beam diameter as small as possible at the location of the discontinuity.

### 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 echo amplitude falls to 6 dB below the last maximum or at which, in the case of back-wall echo reduction, the echo is reduced by 6 dB (2 MHz probe) below the height of the undisturbed back-wall echo.

### 5.5.7.3 Sizing of discontinuities in the through-wall direction

The sizing of planar discontinuities and their assessment in relation to specified classes shall be carried out by probe movement in accordance with [5.5.7.1](#), but in this case, the echo is reduced by 20 dB (see [Figures C.7](#) and [C.9](#)).

The dimension in the through-wall direction of the discontinuity shall be measured according to [Figure 6](#).

## 5.6 Test report

The test report shall contain at least the following information:

- a) a reference to this document i.e. ISO 4992-2:2020;
- b) characteristic data of the tested casting;
- c) extent of testing;
- d) type of test equipment used;
- e) probes used;
- f) the test technique with reference to the tested area (range setting);
- g) all data necessary for sensitivity setting (calibration blocks);

- h) information on all characteristic features of discontinuities to be recorded (e.g. back-wall echo reduction, position and dimension in the through-wall direction, length, area and equivalent flat-bottomed hole diameter) and the descriptions of their position (sketch or photograph);
- i) date of the testing and name and signature of the responsible person.

**Table 1 — Acceptance levels for discontinuities without measurable dimensions in special rim zones and weld preparation ends (scanned by normal-beam or angle-beam probes)**

| Class <sup>a</sup> | Smallest equivalent flat-bottomed or side-drilled hole diameter to be considered |                                         | Acceptance limits <sup>c</sup> for discontinuities in a frame 100 mm × 100 mm |                  |
|--------------------|----------------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------------------------------------------|------------------|
|                    |                                                                                  |                                         | number max.                                                                   | distance min. mm |
| 1                  | FBH <sup>b</sup><br>mm                                                           | SDH <sup>b</sup><br>mm                  | 6                                                                             | 12               |
| 2                  | 1,5                                                                              | 3 <sup>d,e</sup><br>(with -6 db on DAC) | 12                                                                            | 10               |
| 3                  | 2                                                                                | 3 <sup>d</sup>                          | 12                                                                            | 8                |

<sup>a</sup> Class 1 generally applies to the complete wall thickness of weld preparation ends. The class for special rim zones shall be specified by the purchaser.

<sup>b</sup> FBH = flat-bottomed hole, SDH = side-drilled hole.

<sup>c</sup> If the discontinuities are more than 15 mm apart, they are acceptable, irrespective of their number.

<sup>d</sup> Applicable to angle-beam probes (4 MHz, transducer diameter approx. 10 mm).

<sup>e</sup> A SDH of diameter 0,75 mm can be represented by a SDH of diameter 3 mm, if the distance-amplitude correction curve of a SDH of diameter 3 mm is reduced by 50 %.

**Table 2 — Ultrasonic testability requirements**

Dimensions in millimetres

| Wall thickness | Tested area                             | Smallest flat-bottomed hole diameter detectable according to 5.2 |
|----------------|-----------------------------------------|------------------------------------------------------------------|
| ≤100           | —                                       | 2                                                                |
| >100 to ≤300   | —                                       | 3                                                                |
| >300 to ≤600   | —                                       | 4                                                                |
| —              | Special rim zone, weld preparation ends | 1,5                                                              |

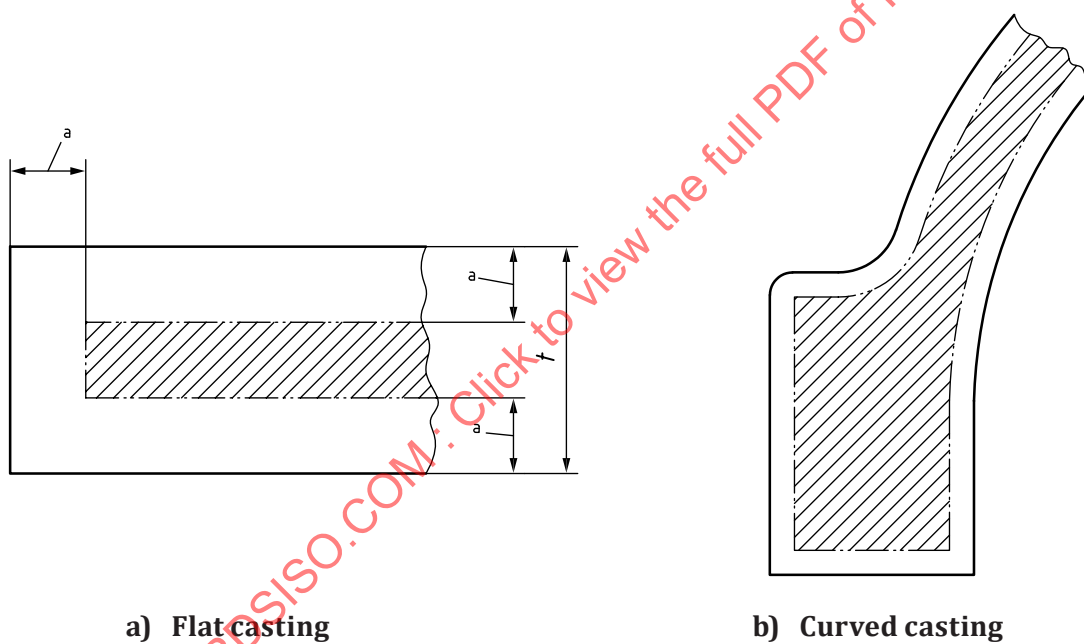
**Table 3 — Recording levels**

| Wall thickness<br>mm | Smallest equivalent flat-bottomed hole diameter<br>mm | Reduction of back-wall echo<br>min. dB |
|----------------------|-------------------------------------------------------|----------------------------------------|
| ≤100                 | 2                                                     | 12                                     |
| >100 to ≤300         | 3                                                     |                                        |
| >300 to ≤600         | 4                                                     |                                        |

Table 4 — Reference codes for types of indications

| Reference code <sup>a</sup> | Type of indication                                                     | Figure                                      |
|-----------------------------|------------------------------------------------------------------------|---------------------------------------------|
| SDB                         | Reduction of back-wall echo                                            | <a href="#">C.2</a>                         |
| II                          | Individual discontinuity without measurable dimension                  | <a href="#">C.3</a> , <a href="#">C.4</a>   |
| IIL                         | Individual discontinuity with one measurable dimension                 | <a href="#">C.4</a> , <a href="#">C.5</a>   |
| GIR                         | Group of resolvable discontinuities                                    | <a href="#">C.6</a>                         |
| IIP/IID                     | Individual discontinuity with two dimensions                           | <a href="#">C.5</a> , <a href="#">C.7</a>   |
| NII                         | Numerous discontinuities without measurable dimensions                 | <a href="#">C.8</a>                         |
| NIP                         | Numerous discontinuities with dimensions in the through-wall direction | <a href="#">C.9</a>                         |
| GIN                         | Group of non-resolvable discontinuities                                | <a href="#">C.10</a> , <a href="#">C.11</a> |

<sup>a</sup> For characterization of indications see ISO 16827:2012, Annex B.

**Key**

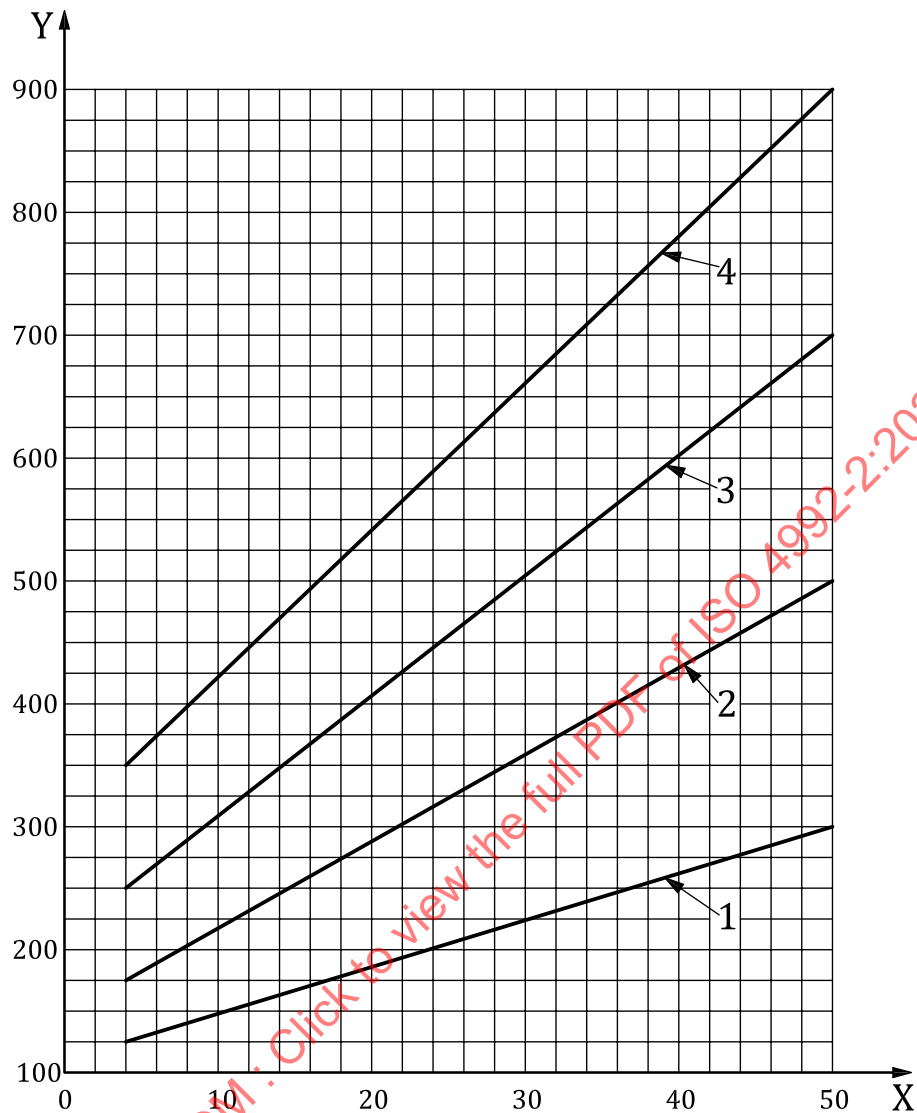
rim zone



core zone

 $t$  wall thickness $a$   $t/3$  (max. 30 mm)

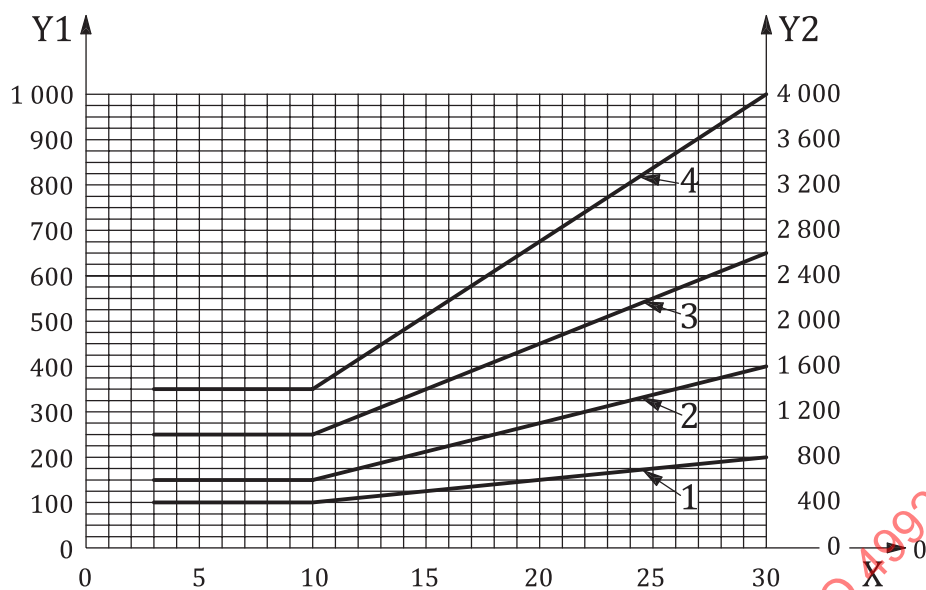
Figure 1 — Division of wall section into zones

**Key**

- 1 class 2
- 2 class 3
- 3 class 4
- 4 class 5
- X distance from test surface, in millimetres
- Y largest acceptable area of an individual discontinuity, in square millimetres

For further explanations, see [Clause 4.3.3.2](#).

**Figure 2 — Acceptance levels for individual planar discontinuities mainly orientated in the through-wall direction (see also [Figures C.8, C.9](#) and [C.11](#)) detected with angle-beam probes**

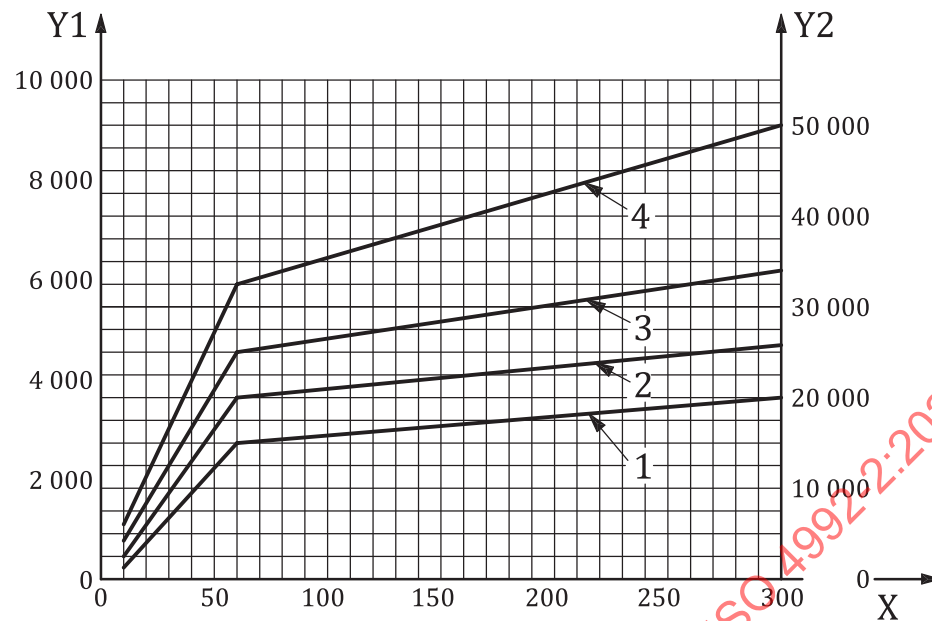


**Key**

- 1 class 2
- 2 class 3
- 3 class 4
- 4 class 5
- X shortest distance from test surface or from back-wall, in millimetres
- Y1 smallest discontinuity area to be recorded, in square millimetres
- Y2 largest acceptable individual discontinuity area, in square millimetres

For further explanations, see [Clause 4.3.3.3](#).

**Figure 3 — Recording and acceptance levels for volumetric discontinuities with measurable dimensions in the rim zone (see also [Figures C.2](#), [C.5](#) and [C.10](#)) detected with normal-beam probes**

**Key**

1 class 2

2 class 3

3 class 4

4 class 5

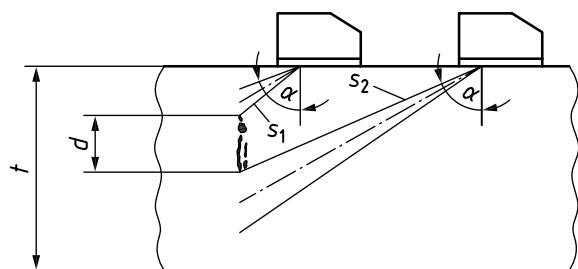
X shortest distance from test surface or from back-wall, in millimetres

Y1 smallest discontinuity area to be recorded, in square millimetres

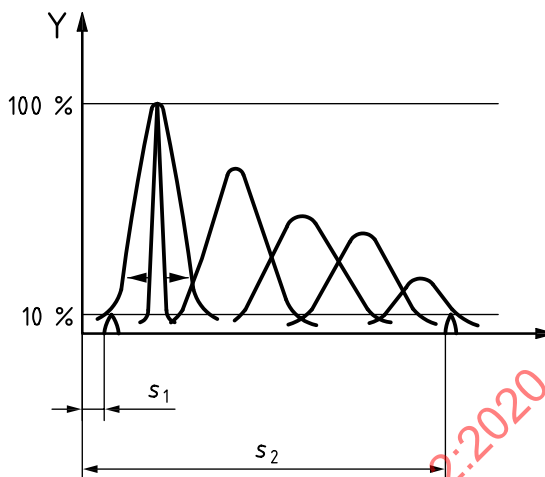
Y2 largest acceptable individual discontinuity area, in square millimetres

For further explanations, see [Clause 4.3.3.3](#).

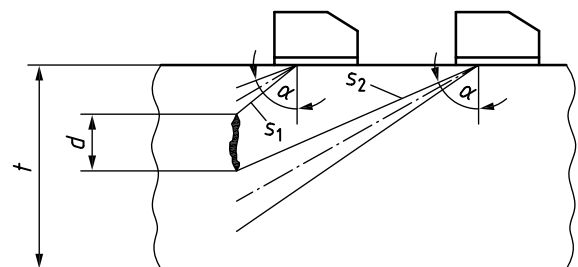
**Figure 4 — Recording and acceptance levels for volumetric discontinuities with measurable dimensions in the core zone (see also [Figures C.2](#), [C.5](#) and [C.10](#)) detected with normal-beam probes**



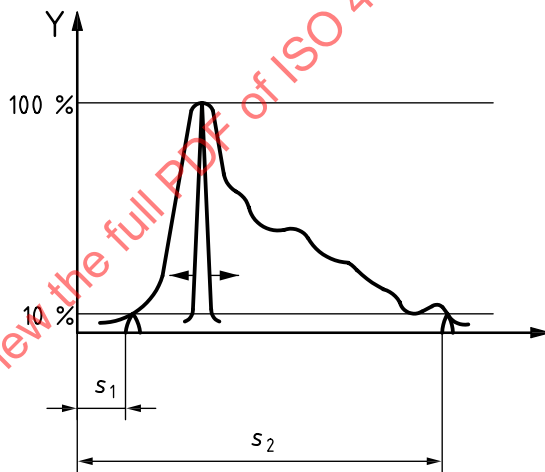
a) Wall section with broken discontinuity



b) Display for Figure 5 a)



c) Wall section with continuous discontinuity

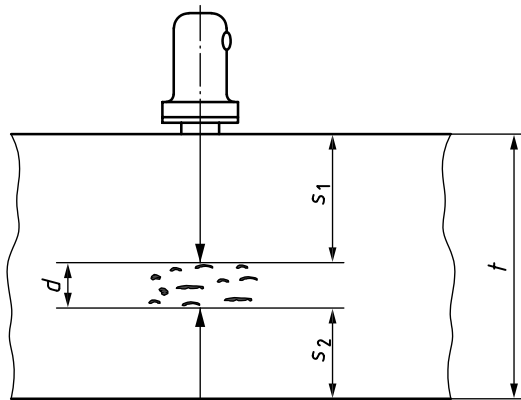


d) Display for Figure 5 c)

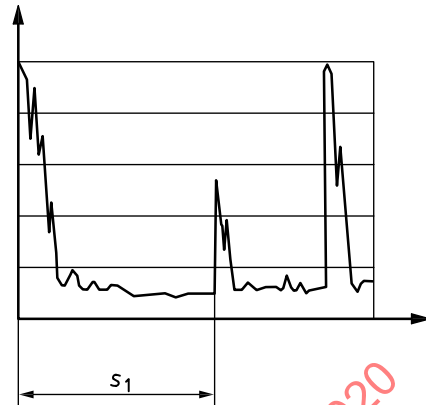
**Key**

- Y echo height  
 $d$  dimension in the through-wall direction  $d = (s_2 - s_1) \cos \alpha$   
 $s_1, s_2$  length of the sound path  
 $t$  thickness  
 $\alpha$  angle of incidence

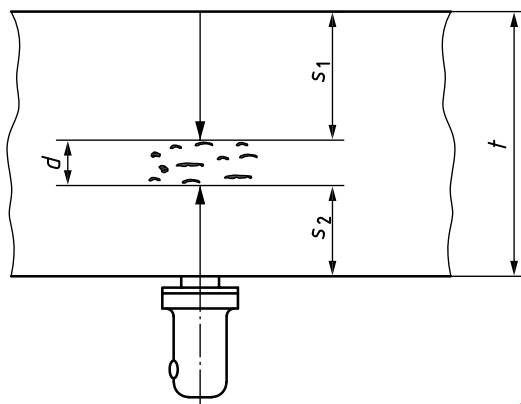
**Figure 5 — Measurement of the dimension of discontinuities in the through-wall direction**



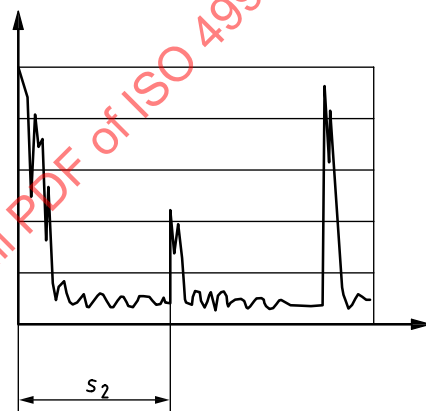
a) Scanning position "A"



b) A-scan from scanning position "A" in Figure 6 a)



c) Scanning position "B"



d) A-scan from scanning position "B" in Figure 6 c)

**Key**

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

$t$  wall thickness

$s_1, s_2$  lengths of the sound path

**Figure 6 — Measurement of the dimension of discontinuities in the through-wall direction with normal-beam probes**

## Annex A

### (normative)

## Resolution of detection of the instrument-probe combination

The resolution of detection of the instrument-probe combination shall be assessed by measuring the duration of the first back-wall echo using the 25 mm thick section of calibration block No. 1 according to ISO 2400. The echo amplitude shall be set at 80 % to 100 % of full screen height and the duration of the echo measured in millimetres of steel at a level of 10 % of the echo height. Typical values are given in [Table A.1](#).

**Table A.1 — Typical values of echo duration in steel**

| Frequency<br>MHz | Echo duration                |                            |
|------------------|------------------------------|----------------------------|
|                  | longitudinal waves (L)<br>mm | transverse waves (T)<br>mm |
| 1                | 15                           | —                          |
| 2 or 2,25        | 9                            | 5                          |
| 4                | 5                            | 3                          |
| 5                | 4                            | 2,5                        |

**Annex B**  
(informative)

**Sound-beam diameters**

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

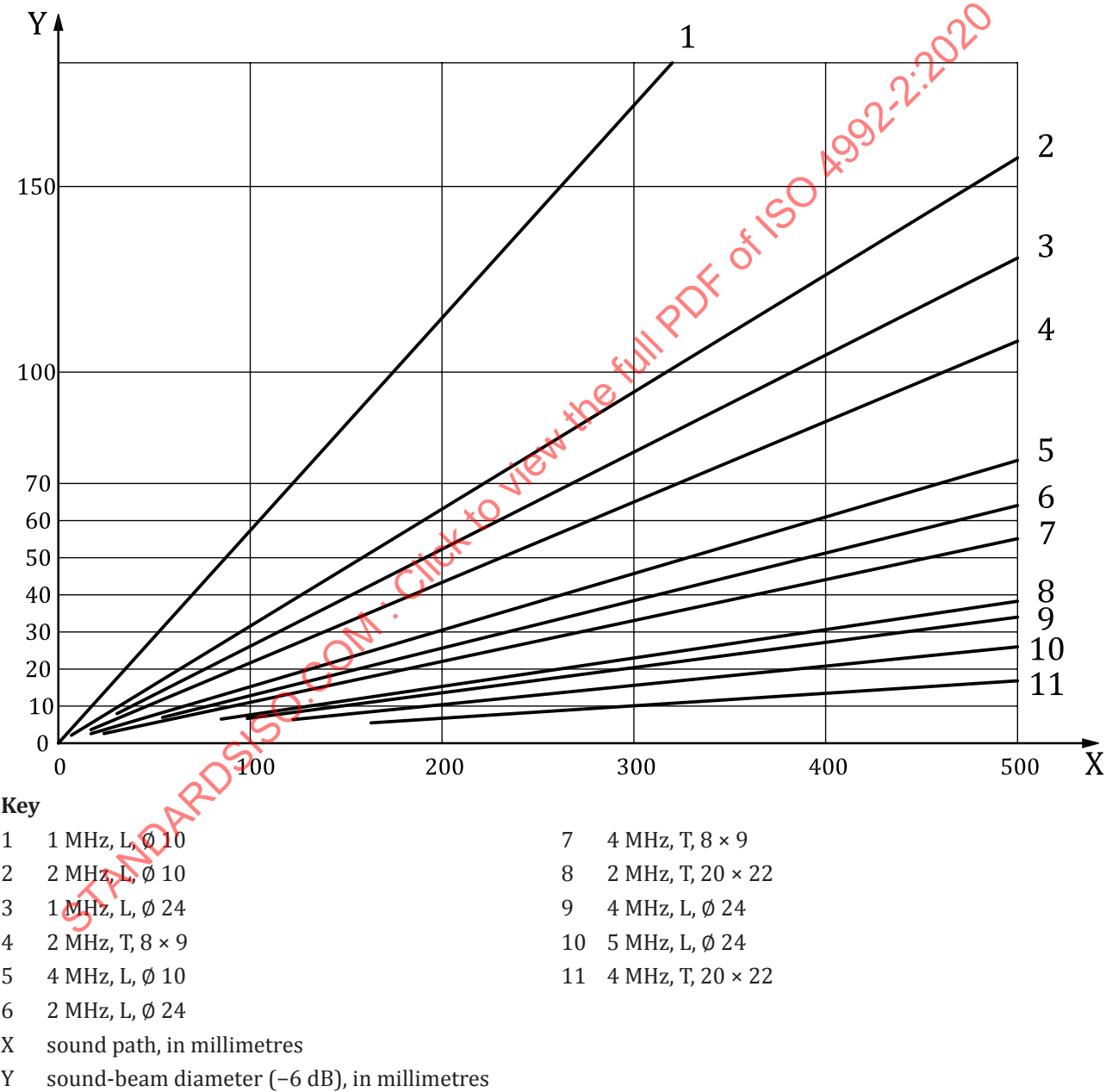


**Figure B.1 — Sound-beam diameters according to sound path and near-field length for various probes**

Table B.1 — Near-field lengths of various probes

| Transducer<br>dimension<br><br>mm | Near-field length in millimetres<br>(approximate values) |       |       |       |                      |       |
|-----------------------------------|----------------------------------------------------------|-------|-------|-------|----------------------|-------|
|                                   | longitudinal waves (L)                                   |       |       |       | transverse waves (T) |       |
|                                   | 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   |

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

$$N = \frac{D_c^2}{4\lambda} \quad (\text{B.1})$$

$$D_F = \frac{\lambda s}{D_c} \quad (\text{B.2})$$

where

$N$  is the near-field length, in millimetres;

$D_c$  is the transducer diameter, in millimetres;

$\lambda$  is the wavelength, in millimetres;

$s$  is the sound path, in millimetres;

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

## **Annex C**

### **(informative)**

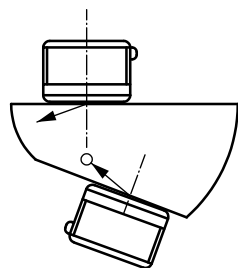
### **Types of indications generated by typical discontinuities**

[Figures C.1](#) to [C.11](#) show how typical types of indications and their echo dynamics are linked to typical types of discontinuities.

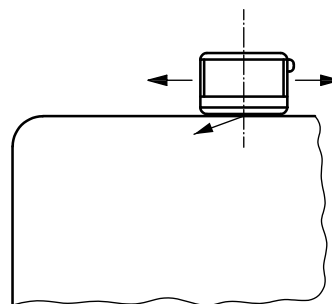
For the identification of the discontinuity type, the test sensitivities may be changed according to:

- a) the distance between the test surface and the discontinuity;
- b) the geometrical shape of the discontinuity;
- c) the test surface finish.

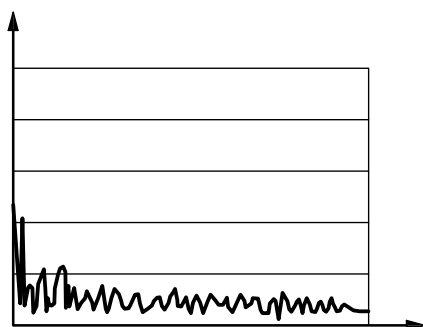
STANDARDSISO.COM : Click to view the full PDF of ISO 4992-2:2020



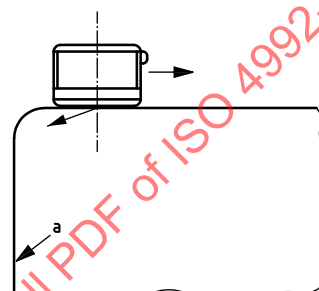
a) Probe positions on calibration block no. 2



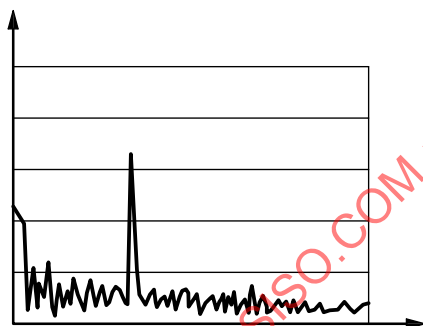
b) Probe on test object without discontinuities



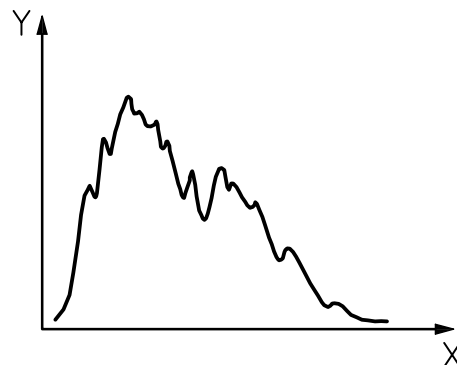
c) Display for Figure C.1 b) showing the average noise level



d) Probe on test object with discontinuity



e) Display for Figure C.1 d) showing the echo of the discontinuity



f) Typical echo dynamic pattern

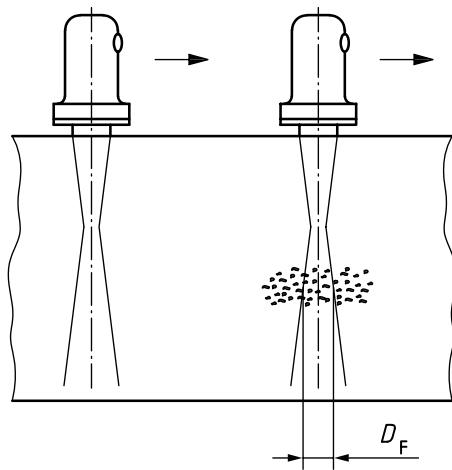
**Key**

X probe movement

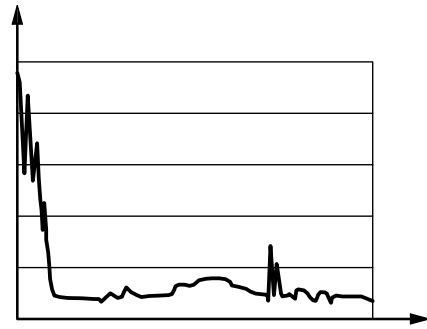
Y echo height

a As-cast surface.

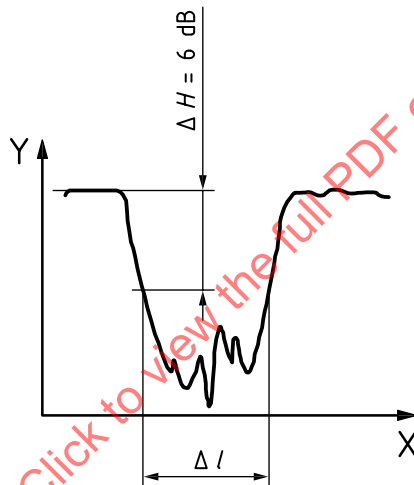
**Figure C.1 — Range setting and sensitivity setting of the ultrasonic instrument when scanning with a dual-element angle-beam probe (4 MHz, 60° angle) to detect discontinuities with a measurable dimension mainly orientated in the through-wall direction in the rim zone**



a) Probe positions



b) Display with echo of discontinuities



c) Back-wall echo drop

**Key** $\Delta H$  reduction of back-wall echo

X probe movement

Y echo height

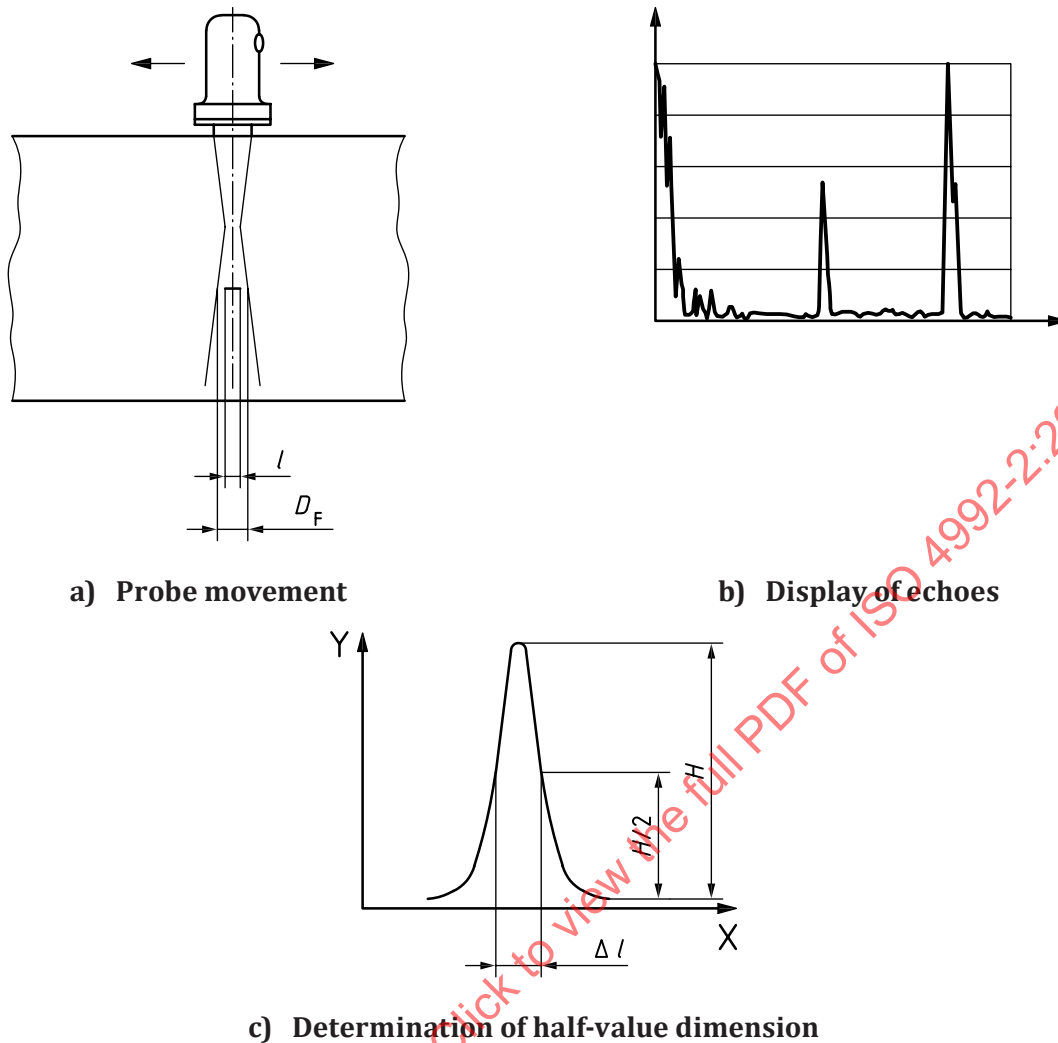
Typical indication:

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

Origin: Spongy shrinkage, gas holes, inclusions or large inclined discontinuity.

where

 $D_F$  is the sound-beam diameter; $\Delta l$  is the dimension of the discontinuity.**Figure C.2 — Reduction of back-wall echo by more than 12 dB, measurable dimension of a discontinuity**



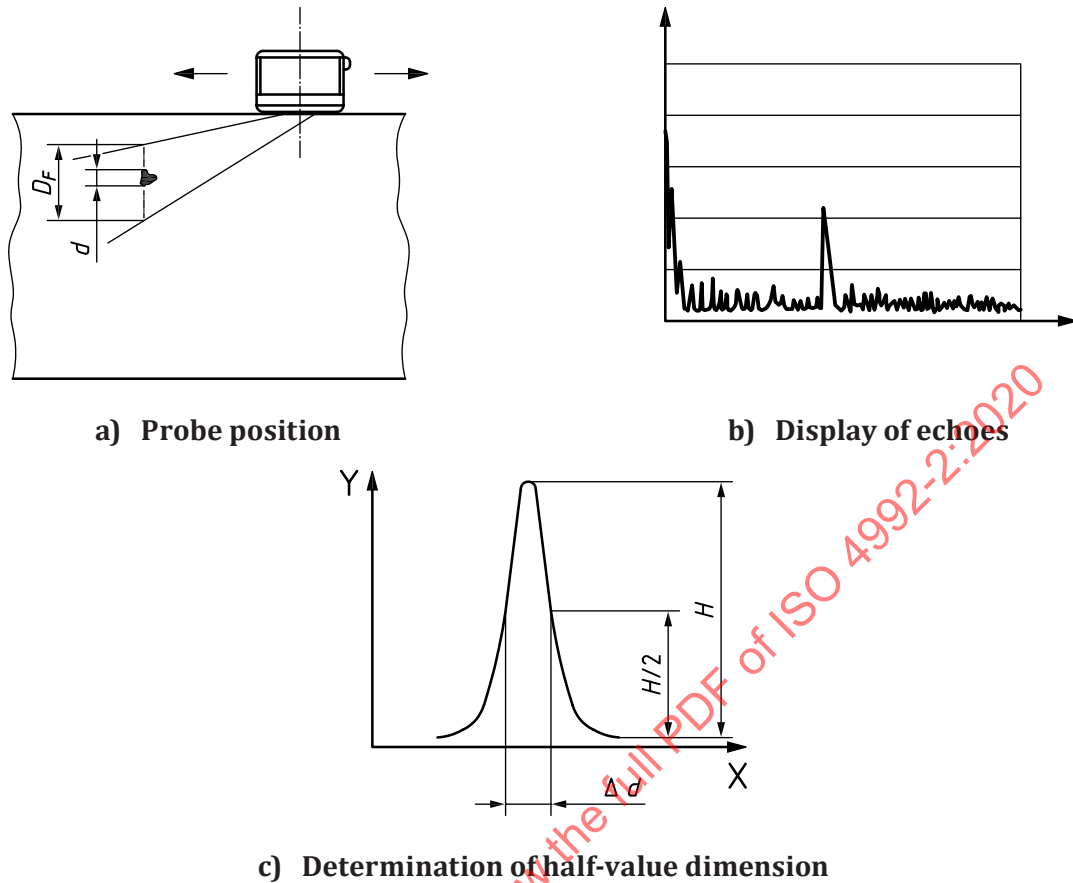
**Key**

- $l$  lateral extension of discontinuity
- $\Delta l$  half-value dimension of indication
- $H$  maximum echo height of individual indication
- $X$  probe movement
- $Y$  echo height

Typical indication:

Individual indication, half-value dimension  $\Delta l$  smaller than or equal to the sound-beam diameter  $D_F$  at reflection point.

**Figure C.3 — Individual discontinuity without measurable dimensions**



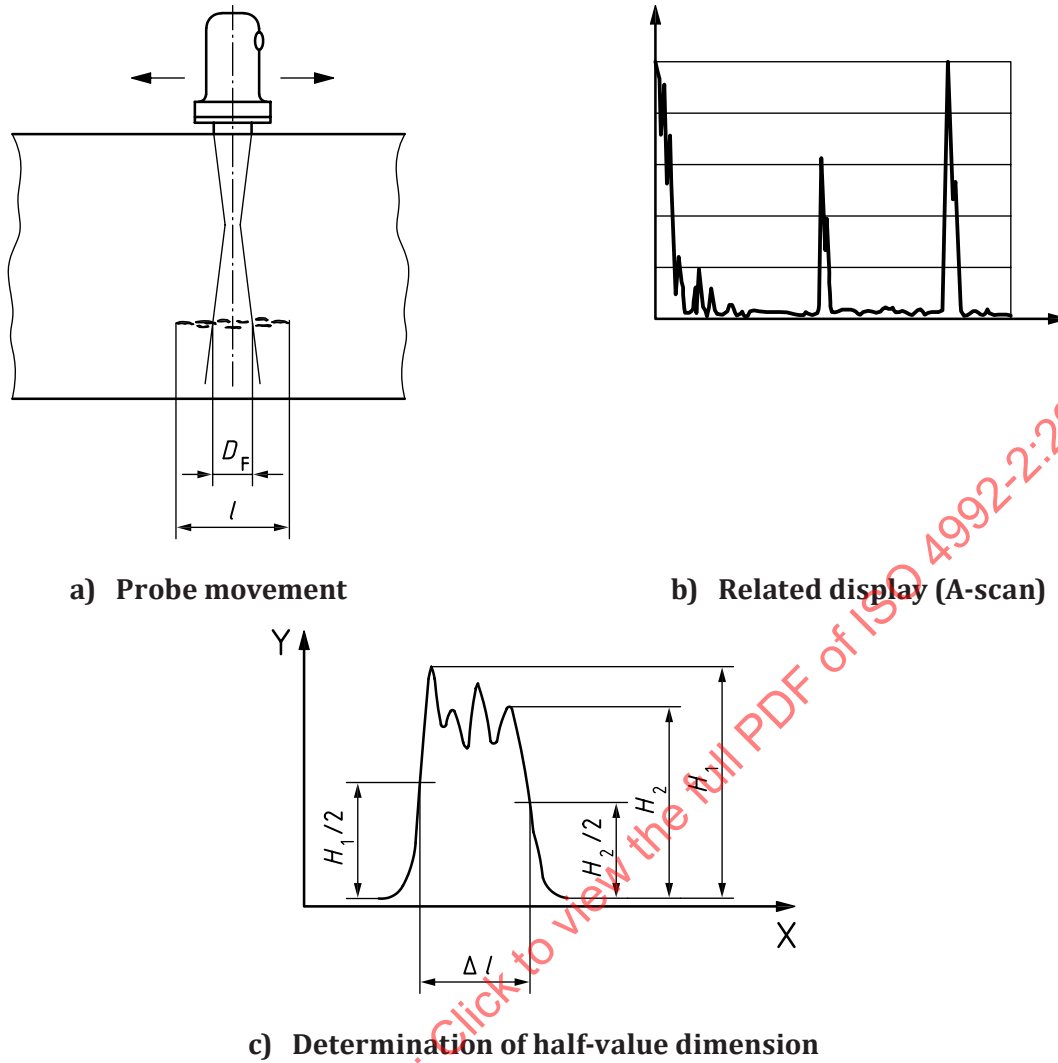
#### Key

- $d$  dimension of discontinuity in the through-wall direction
- $\Delta d$  half-value dimension of indication
- $H$  maximum echo height of individual indication
- $X$  probe movement
- $Y$  echo height

Typical indication:

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

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



**Key**

|            |                                                           |
|------------|-----------------------------------------------------------|
| $l$        | lateral dimension of discontinuity                        |
| $\Delta l$ | half-value dimension of indication                        |
| $H_1, H_2$ | last maximum echo heights on opposite sides of indication |
| $X$        | probe movement                                            |
| $Y$        | echo height                                               |

Typical indication:

Individual discontinuities, mainly from the same position in the through-wall direction.

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

**Figure C.5 — Individual discontinuity with measurable dimensions: measurable length, non-measurable width; measurable length, measurable width**