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BSI Standards Publication

Non-destructive testing of welds - Ultrasonic testing - Characterization of discontinuities in welds (ISO 23279:2017)

bsi.

National foreword

This British Standard is the UK implementation of EN ISO 23279:2017. It is identical to ISO 23279:2017. It supersedes BS EN ISO 23279:2010, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/46, Non-destructive testing.

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Essais non destructifs des assemblages soudés - Contrôle par ultrasons - Caractérisation des discontinuités dans les assemblages soudés (ISO 23279:2017)

Zerstörungsfreie Prüfung von Schweißverbindungen - Ultraschallprüfung - Charakterisierung von Inhomogenitäten in Schweißnähten (ISO 23279:2017)

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European foreword

This document (EN ISO 23279:2017) has been prepared by Technical Committee ISO/TC 44 “Welding and allied processes” in collaboration with Technical Committee CEN/TC 121 “Welding and allied processes” the secretariat of which is held by DIN.

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Foreword

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

This third edition cancels and replaces the second edition (ISO 23279:2010), which has been technically revised.

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Non-destructive testing of welds — Ultrasonic testing — Characterization of discontinuities in welds

1 Scope

This document specifies how to characterize indications from discontinuities by classifying them as originating from planar or non-planar embedded discontinuities.

This procedure is also suitable for indications from discontinuities that break the surface after removal of the weld reinforcement.

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 11666, *Non-destructive testing of welds — Ultrasonic testing — Acceptance levels*

ISO 17640, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment*

3 Terms and definitions

No terms and definitions are listed in this document.

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Principle

Classification of discontinuities as planar or non-planar is based on several parameters:

a) welding techniques;

b) geometrical position of the discontinuity;

c) maximum echo amplitude;

d) directional reflectivity;

e) echo static pattern (i.e. A-scan);

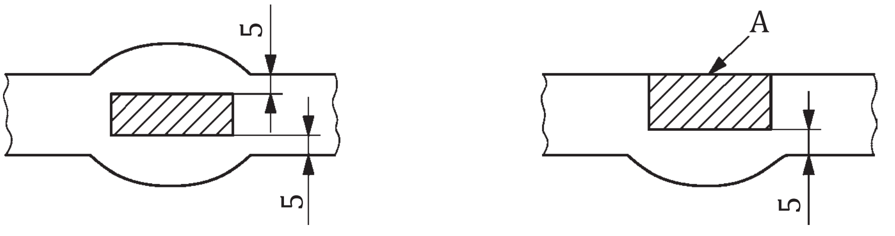
f) echo dynamic pattern (envelope).

The process of classification involves examining each of the parameters against all the others in order to arrive at an accurate conclusion.

For guidance, Figure A.1 gives the classification of indications from internal weld discontinuities suitable for general applications. Figure A.1 should be applied in conjunction with the two parameters a) and b) listed above and not taken in isolation.

The classification procedure specified in this document is also suitable for indications that come from surface breaking discontinuities after removal of the weld reinforcement (see Figure 1).

Dimensions in millimetres



Key
A ground weld

Figure 1 — Origin of indications from a weld

5 Criteria

5.1 General

The classification is carried out by the successive application of several discriminatory criteria to:

a) echo amplitude;

b) directional reflectivity;

c) echo static pattern (A-scan);

d) echo dynamic pattern (envelope).

These criteria shall be applied using the flowchart procedure according to Annex A and as described in Clause 5.

It is recommended that the same probes be used for detection and for classification of discontinuities. The flowchart procedure standardizes a system of classification. Several thresholds are defined in decibels by a comparison with the distance-amplitude curve (DAC) or by a comparison of the maximum echo heights from the discontinuity when tested from different directions.

Proposed thresholds for the different stages in the flowchart procedure are given in Table A.1.

The flowchart procedure calls for five stages:

— stage 1: to avoid the classification of indications with very low echo amplitudes;

— stage 2: to classify all indications with high echo amplitude as associated with planar discontinuities;

— stage 3: primarily to classify lack of fusion;

— stage 4: primarily to classify inclusions;

— stage 5: primarily to classify cracks.

NOTE Indications resulting from a combination of an inclusion and lack of fusion are classified as originating from a planar discontinuity by the flowchart procedure. An example of this type of discontinuity is given in Figure A.2.

5.2 Echo amplitude criteria (stages 1 and 2)

5.2.1 Low amplitudes (stage 1)

It is accepted that an indication with an echo amplitude lower than the evaluation level as specified in ISO 11666 (defined as T_1 in Figure A.1) is not significant and shall not be characterized.

For special applications, this value, T_1, may be lowered, if defined by specification.

5.2.2 High amplitudes (stage 2)

It is assumed that an indication with an echo amplitude that is at least equal to the reference level plus 6 dB (defined as T_2 in Figure A.1) is associated with a planar discontinuity.

5.3 Directional reflectivity criteria (stage 3)

5.3.1 Applicability based on length

Stage 3 of the flowchart procedure shall be applied only to those indications exceeding:

a) thickness t for the range 8 mm ≤ t ≤ 15 mm;

b) $t/2$ or 15 mm, whichever is larger, for thicknesses over 15 mm.

For indications not exceeding the specified length, proceed to stage 4.

5.3.2 Application conditions

The following application conditions apply:

a) Echoes compared shall be obtained from the same reflector.

b) The comparison shall be made at the position where echo height, $H_{d,\,max}$, is the highest along the indication.

c) When a normal-beam probe and an angle-beam probe are used, their frequencies shall be chosen to give similar wavelengths (e.g. 4 MHz for longitudinal waves and 2 MHz for transverse waves for steel).

d) When two or more beam angles are used, the differences between the nominal refracted beam angles shall be equal to or greater than 10°.

e) If the comparison is made between a beam passing through the weld and a beam passing through the base material only, the attenuation of the weld material shall be taken into account.

5.3.3 Criteria

The highest echo amplitude, $H_{d,\,max}$, obtained from the discontinuity is compared with the minimum echo amplitude, $H_{d,\,min}$, obtained from all the other directions.

To satisfy the directional reflectivity, the following conditions shall be fulfilled simultaneously:

a) $H_{d,\,max}$ is greater than or equal to T_3 (the reference level − 6 dB).

b) The modulus of the difference of the amplitudes of the indications, $|H_{d,\,max} - H_{d,\,min}|$, from two different directions is at least

   1) 9 dB using transverse wave angle-beam probes only, or

   2) 15 dB using one transverse wave angle-beam probe and one longitudinal wave normal-beam probe.

The directional reflectivities depend on the angle of refraction and the test conditions (half skip, full skip).

Examples of different testing directions are given in Figure B.1.

An example of the application of these criteria is given in Figure B.2.

5.4 Echo static pattern criteria (stage 4)

At this stage, the echo static pattern (i.e. A-scan) of the discontinuity is compared with that obtained from the reference reflector (3 mm diameter side-drilled hole).

If the echo static pattern is single and smooth, the discontinuity is classified as non-planar.

If the echo static pattern is not both single and smooth, proceed to stage 5.

These criteria shall be fulfilled for at least two directions of testing.

5.5 Transverse echo dynamic pattern criteria (stage 5)

The transverse echo dynamic pattern of a discontinuity is the envelope of the resulting echoes when the ultrasonic probe is moved perpendicular to the discontinuity in accordance with ISO 17640. The analysis takes into account not only the envelope, but also the behaviour of the echoes inside of it.

Classification of discontinuities depends on the patterns observed:

— pattern 1: single, non-planar discontinuity;

— pattern 2: excluded by previous stage;

— pattern 3 and pattern 4: planar discontinuity, if observed for the two directions of highest reflectivity; if only observed for one reflectivity direction, use complementary tests (see 5.6);

— pattern 5: cluster of non-planar discontinuities.

These patterns used for classification are given in Annex C.

These criteria shall be fulfilled for at least two directions of testing.

5.6 Complementary testing

In case of doubt, carry out additional tests, for example:

a) use of additional reflectivity directions or additional probes;

b) analysis of the echo dynamic pattern when the probe is moved parallel to the discontinuity [see Figure C.1 c), Figure C.2 c), Figure C.3 c), Figure C.4 c) and Figure C.5 c)];

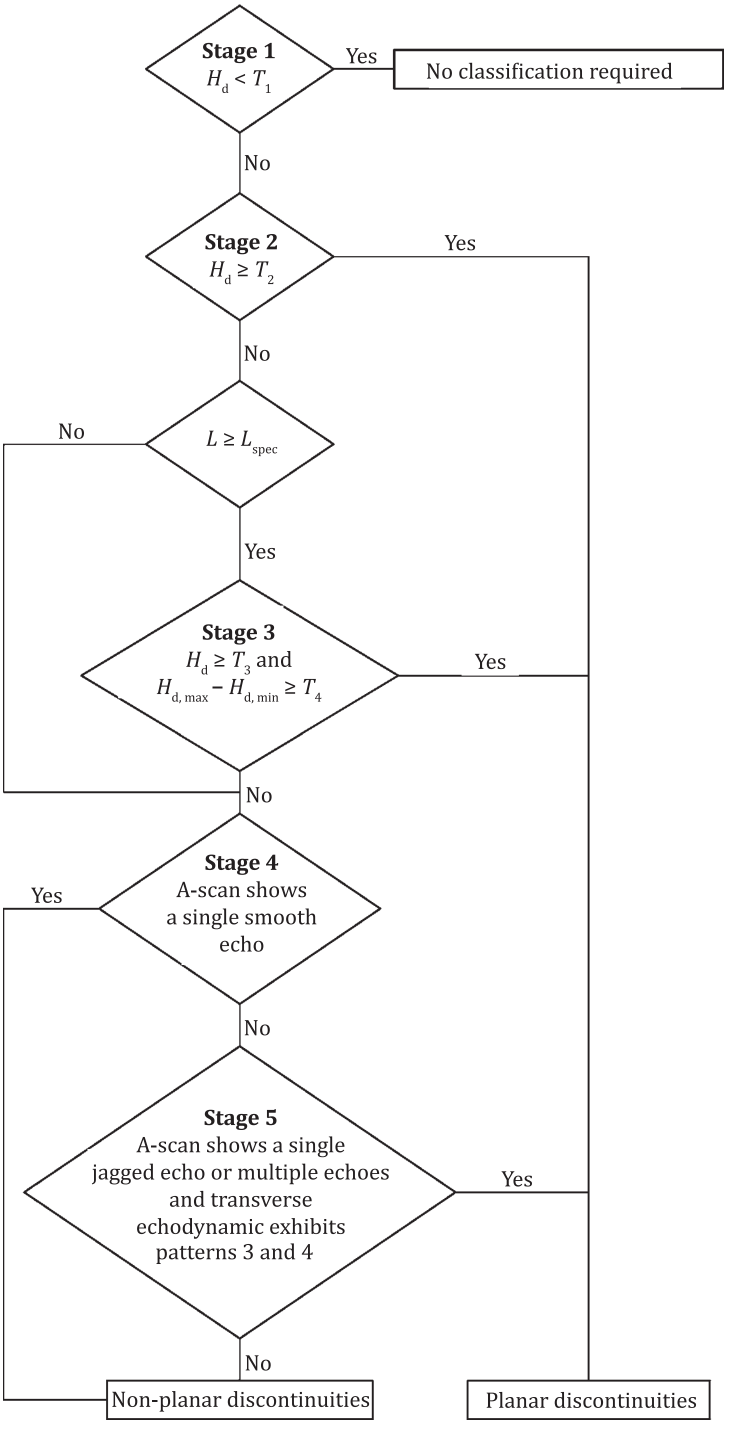
c) other non-destructive testing methods (e.g. radiography).

This list is not restrictive.

Annex A
(normative)

Classification of indications from internal discontinuities in welds — Flowchart procedure

The flowchart procedure is defined in Figure A.1.



Key

H_d	indication echo amplitude
$H_{d, max}$	maximum echo amplitude
$H_{d, min}$	minimum echo amplitude
L	length
L_{spec}	specified length
T_1, T_2, T_3, T_4	see Table A.1

Figure A.1 — Flowchart procedure

Table A.1 — Different thresholds used in the flowchart procedure

Threshold	T_1	T_2	T_3	T_4
Threshold values	Evaluation level	Reference level + 6 dB	Reference level − 6 dB	9 dB[a] or 15 dB[b]

[a] For transverse waves.

[b] Between reflections obtained with transverse waves and longitudinal waves.

Stage 1 (T_1, i.e. evaluation level): All indications < T_1 are not classified.

Stage 2 (T_2, i.e. reference level + 6 dB): An indication being at least twice as reflective as the reference reflector is classified as associated with a planar discontinuity.

Stage 3 (T_3, i.e. reference level − 6 dB): If the echo amplitude of the indication is at least half of the reference echo and, if the imbalance in reflectivity is greater than or equal to T_4, the indication is classified as associated with a planar discontinuity:

— with T_4 = 9 dB for transverse waves;

— with T_4 = 15 dB between reflections obtained with transverse waves and with longitudinal waves.

The angles at which the ultrasonic beam is incident upon the discontinuity shall have a difference of at least 10°. The comparison shall be made upon the same area of the discontinuity.

Stages 4 and 5: These criteria shall be fulfilled for at least two directions of testing.

Stage 5: If the echo dynamic pattern does not match pattern 3, the indication is classified as associated with a non-planar discontinuity.

The echo patterns are those defined in Annex C.

Indications resulting from a combination of an inclusion and lack of fusion are classified as associated with a planar discontinuity by the flowchart procedure. An example of this type of discontinuity is given in Figure A.2.

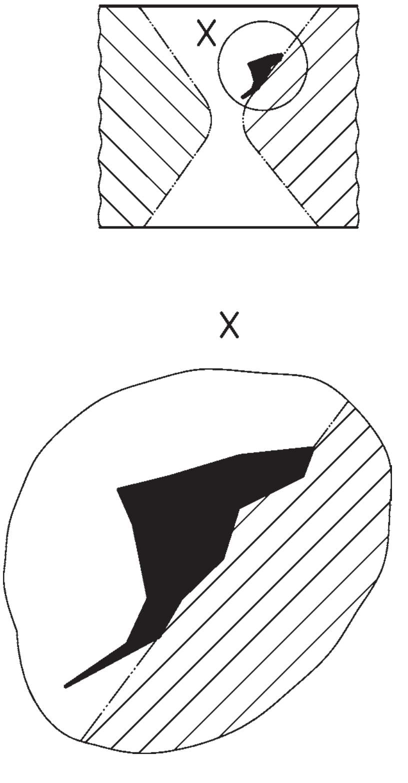
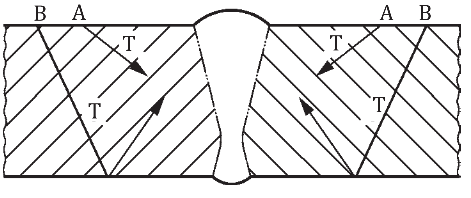


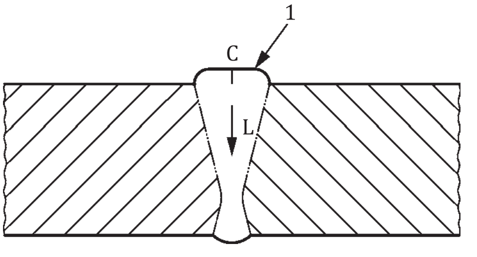
Figure A.2 — Example of a combination of inclusion and lack of fusion

Annex B
(informative)

Directional reflectivity



a) Transverse waves, T

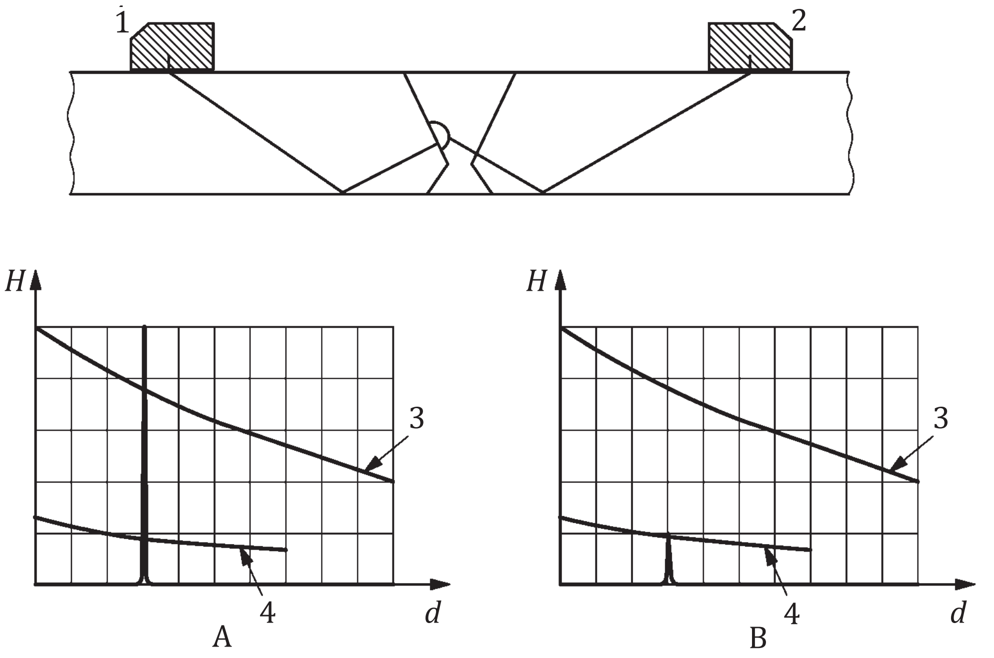


b) Longitudinal waves, L

Key

A, B, C probe positions
L longitudinal waves
T transverse waves
1 local grinding

Figure B.1 — Examples of testing directions



Key

A display when using position 1

B display when using position 2

1 position 1

2 position 2

3 reference level

4 reference level − 9 dB

d sound path

H amplitude

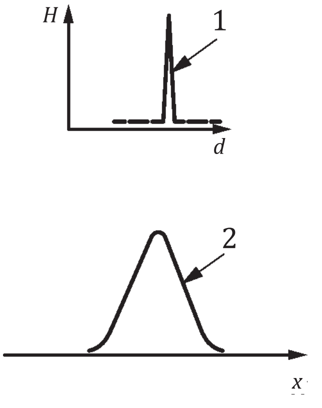
Figure B.2 — Example of application of directional reflectivity criteria

Annex C
(informative)

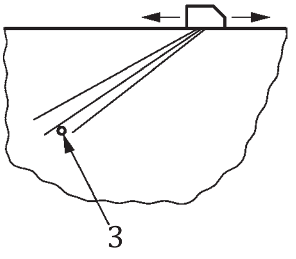
Basic echo dynamic patterns of reflectors

C.1 Pattern 1

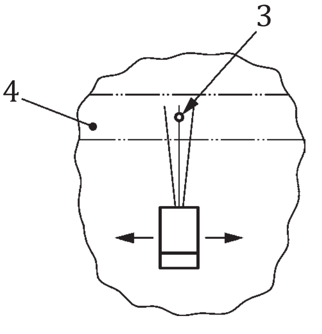
A point-like reflector response is shown in Figure C.1. At any probe position, the A-scan shows a single sharp echo. As the probe is moved, it rises in amplitude smoothly to a single maximum before falling smoothly to noise level.



a) Probe position of A-scan and variation in signal amplitude



b) Typical occurrence in through-thickness direction



c) Typical occurrence in lateral (length) direction

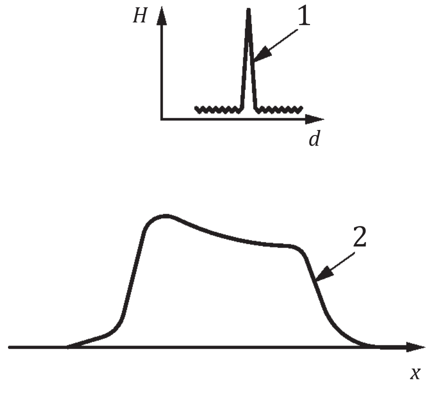
Key

1 A-scan
2 variation in signal peak amplitude
3 reflector
4 weld
d range
H amplitude
x probe position

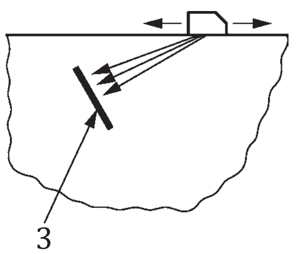
Figure C.1 — Pattern 1 ultrasonic response

C.2 Pattern 2

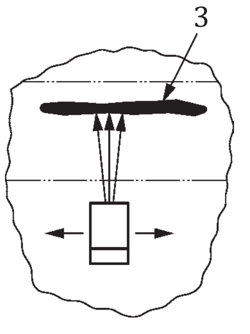
An extended smooth reflector response is shown in Figure C.2. At any probe position, the A-scan shows a single sharp echo. When the ultrasonic beam is moved over the reflector, the echo rises smoothly to a plateau and is maintained, with minor variations in amplitude of up to 4 dB, until the beam moves off the reflector, when the echo falls smoothly to noise level.



a) Probe position of A-scan and variation in signal amplitude



b) Typical occurrence in through-thickness direction



c) Typical occurrence in lateral (length) direction

Key

1 A-scan

2 variation in signal peak amplitude

3 reflector

d range

H amplitude

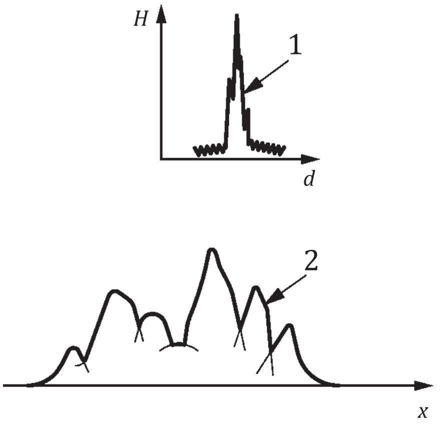
x probe position

Figure C.2 — Pattern 2 ultrasonic response

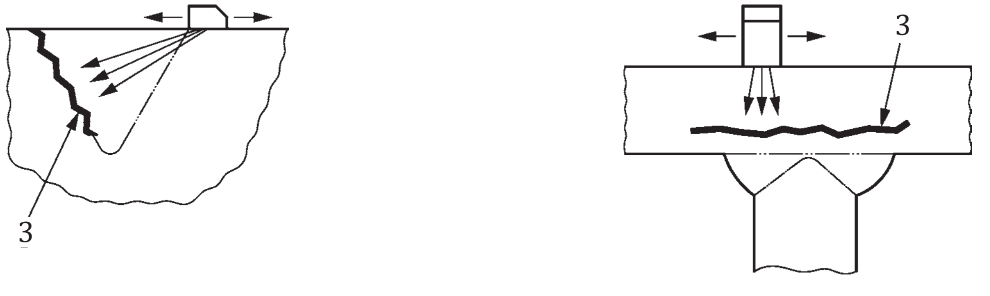
C.3 Pattern 3

There are two variants of an extended rough reflector response depending upon the angle of incidence of the beam on the reflector.

One variant, at near normal incidence, is shown in Figure C.3. At any probe position, the A-scan shows a single but ragged echo. As the probe is moved, this may undergo large (greater than ±6 dB) random fluctuations in amplitude. The fluctuations are caused by reflection from different facets of the reflector and by random interference of waves scattered from groups of facets.



a) Probe position of A-scan and variation in signal amplitude



b) Typical occurrence in through-thickness direction

c) Typical occurrence in lateral (length) direction

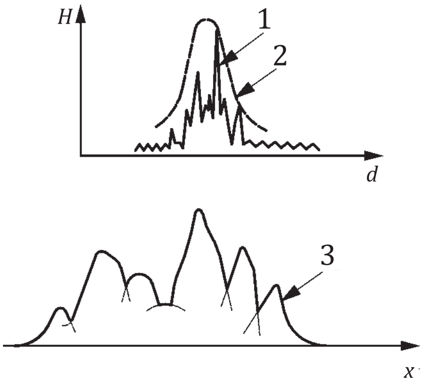
Key

1 A-scan
2 variation in signal peak amplitude
3 reflector
d range
H amplitude
x probe position

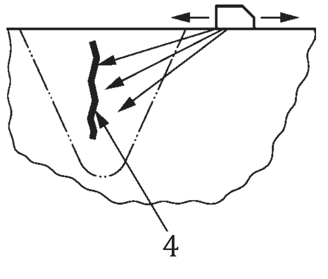
Figure C.3 — Pattern 3 ultrasonic response

C.4 Pattern 4

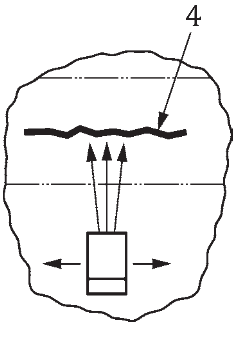
The second variant of an extended rough reflector response, oblique incidence, “travelling echo pattern”, is shown in Figure C.4. At any probe position, the A-scan shows an extended train of signals (“subsidiary peaks”) within a bell-shaped pulse envelope. As the probe is moved, each subsidiary peak travels through the pulse envelope, rising to its own maximum towards the centre of the envelope and then falling. The overall signal may show large (greater than ±6 dB) random fluctuations in amplitude.



a) Probe position of A-scan and variation in signal amplitude



b) Typical occurrence in through-thickness direction



c) Typical occurrence in lateral (length) direction

Key

1 A-scan

2 pulse envelope

3 variation in signal peak amplitude

4 reflector

d range

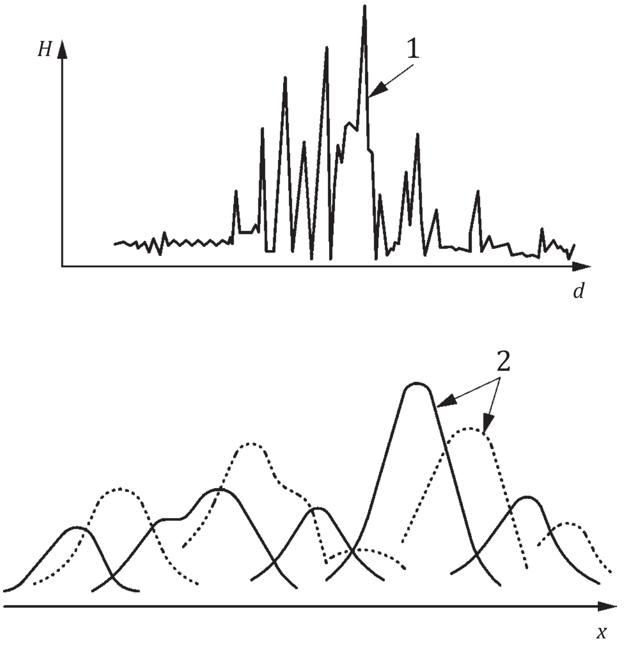
H amplitude

x probe position

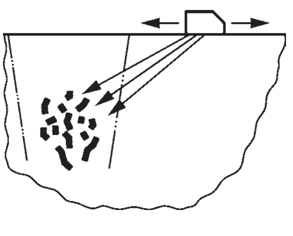
Figure C.4 — Pattern 4 ultrasonic response

C.5 Pattern 5

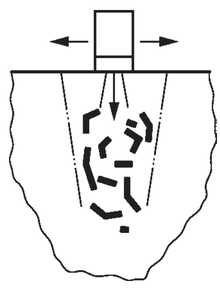
A multiple reflector response is shown in Figure C.5. At any probe position, the A-scan shows a cluster of signals which may or may not be well-resolved in range. As the probe is moved, the signals rise and fall at random, but the signal from each separate reflector element, if resolved, shows a pattern 1 response.



a) Probe position of A-scan and variation in signal amplitude



b) Typical occurrence in through-thickness direction



c) Typical occurrence in lateral (length) direction

Key

1 A-scan
2 variation in signal peak amplitude
continuous lines: long-range echoes
dotted lines: short-range echoes
d range
H amplitude
x probe position

Figure C.5 — Pattern 5 ultrasonic response

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