
**Non-destructive testing of welds —
Ultrasonic testing — Characterization of
indications in welds**

*Contrôle non destructif des assemblages soudés — Contrôle par
ultrasons — Caractérisation des indications dans les assemblages
soudés*



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Published in Switzerland

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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.

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ISO 23279 was prepared by the European Committee for Standardization (CEN) Technical Committee TC 121, *Welding*, in collaboration with ISO Technical Committee TC 44, *Welding and allied processes*, Subcommittee SC 5, *Testing and inspection of welds*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 23279:2007), which has been technically revised.

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

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

1 Scope

This International Standard specifies how to characterize embedded indications by classifying them as planar or non-planar.

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

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

3 Principle

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

- a) welding techniques;
- b) geometrical position of the indication;
- c) maximum echo amplitude;
- d) directional reflectivity;
- e) echostatic pattern (i.e. A-scan);
- f) echodynamic pattern.

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 internal weld indications suitable for general applications. Figure A.1 should be applied in conjunction with the two first parameters listed above and not taken in isolation.

The classification procedure specified in this International Standard is also suitable for indications that are surface breaking after removal of the weld reinforcement (see Figure 1).

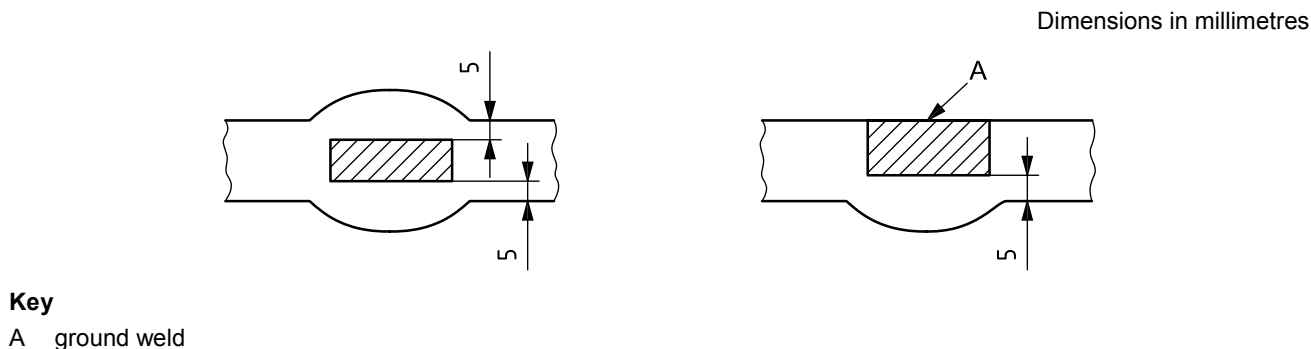


Figure 1 — Location of indications in a weld

4 Criteria

4.1 General

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

- a) echo amplitude;
- b) directional reflectivity;
- c) echostatic pattern (A-scan);
- d) echodynamic pattern.

These criteria are applied using a flowchart procedure (see Annex A).

It is recommended that the same probes be used for detection of indications and for classification. 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 between 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:

- a) stage 1: to avoid the classification of indications with very low echo amplitudes;
- b) stage 2: to classify all indications with high echo amplitude as planar;
- c) stage 3: primarily to classify lack of fusion;
- d) stage 4: primarily to classify inclusions;
- e) stage 5: primarily to classify cracks.

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

4.2 Echo amplitude criteria (stages 1 and 2)

4.2.1 Low amplitudes (stage 1)

It is accepted that an indication with an echo amplitude lower than the evaluation level as specified in ISO 11666 ^[1] (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.

4.2.2 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 a planar indication.

4.3 Directional reflectivity criteria (stage 3)

4.3.1 Applicability based on length

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

- a) l for the range of thicknesses $8 \text{ mm} \leq t \leq 15 \text{ mm}$;
- b) $l/2$ or 15 mm, whichever is the larger, for thicknesses over 15 mm.

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

4.3.2 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 straight 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 shear waves);
- d) when two or more probe angles are used, the differences between the nominal refraction 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 shall be taken into account.

4.3.3 Criteria

The highest echo amplitude, $H_{d, \max}$, obtained from the indication is compared to 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 minus 6 dB);
- b) the modulus of the difference in indication echo amplitudes, $|H_{d, \max} - H_{d, \min}|$, from two different directions is at least:

- 1) 9 dB using shear wave angle beam probes only, or
- 2) 15 dB using one shear wave angle beam probe and one longitudinal wave normal beam probe.

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

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

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

4.4 Echostatic pattern criteria (stage 4)

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

If the echostatic pattern is single and smooth, the indication is classified as non-planar.

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

This criteria shall be fulfilled for at least two directions of examination.

4.5 Transverse echodynamic pattern criteria (stage 5)

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

Classification of indications depends on the patterns observed.

- a) pattern 1: single non-planar;
- b) pattern 2: excluded by previous stage;
- c) pattern 3 and pattern 4: planar, if observed for the two highest reflectivity directions — if only observed for one reflectivity direction, use complementary examination (see 4.6);
- d) pattern 5: cluster of non-planar.

The patterns used for classification are given in Annex C.

This criteria shall be fulfilled for at least two directions of examination.

4.6 Complementary examination

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

- a) use of additional reflectivity directions or probes;
- b) analysis of echodynamic pattern when the probe is moved parallel to the indication [see Figures C.1 c), C.2 c), C.3 c), C.4 c), C.5 c)].
- c) results from other non-destructive testing (e.g. radiography).

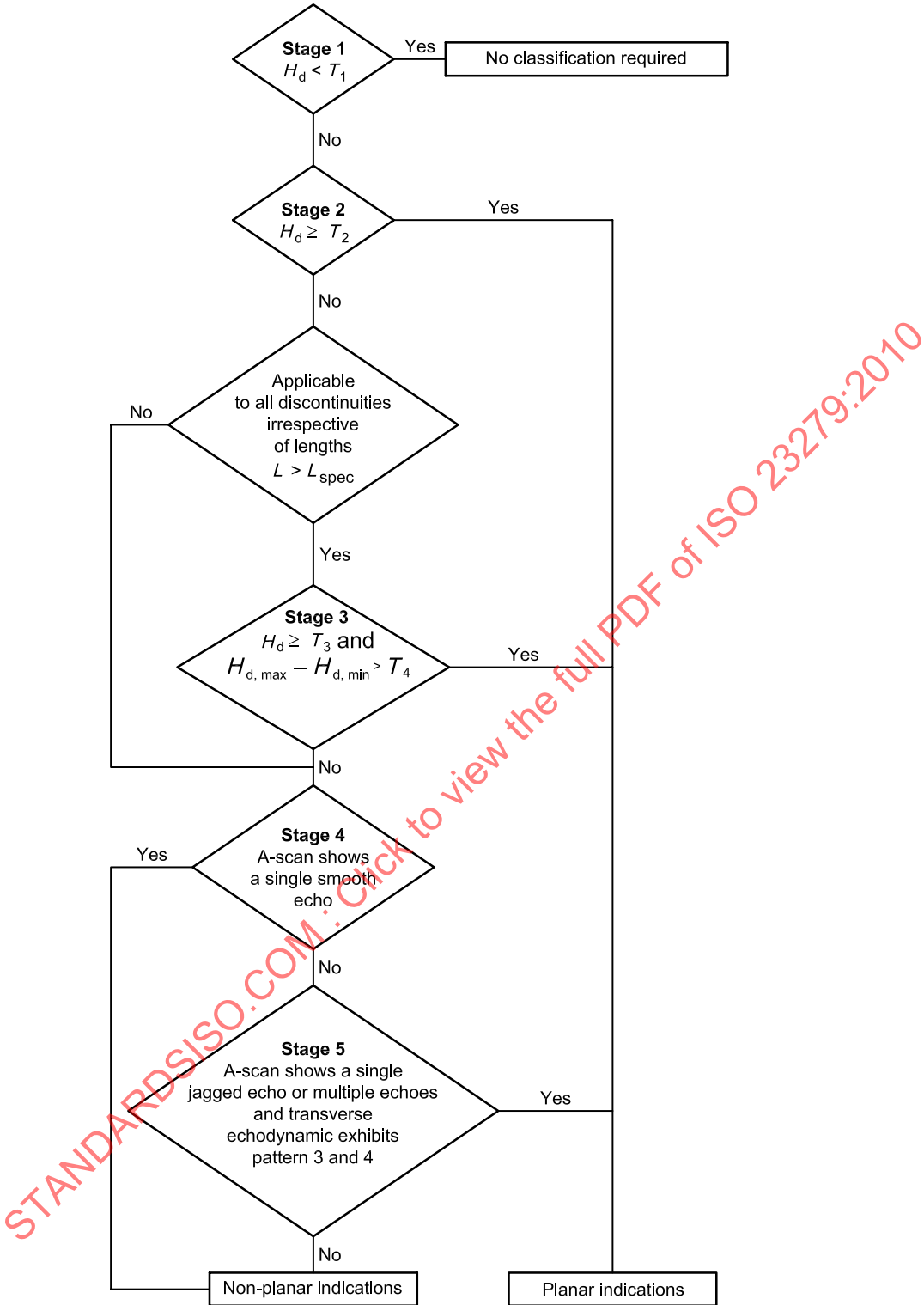
This list is not restrictive.

Annex A
(normative)

Classification of internal indications in welds — Flowchart procedure

The flowchart procedure is defined in Figure A.1.

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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 plus 6 dB	Reference level minus 6 dB	9 dB ^a or 15 dB ^b
^a Shear waves.				
^b Between reflections obtained with a shear wave and a longitudinal wave.				

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

Stage 2 (T_2 , i.e. reference level plus 6 dB): An indication being at least twice as reflective as the reference is classified as planar.

Stage 3 (T_3 , i.e. reference level minus 6 dB): If the indication echo amplitude 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 planar:

- with $T_4 = 9$ dB for shear waves;
- with $T_4 = 15$ dB between reflections obtained with shear waves and longitudinal waves.

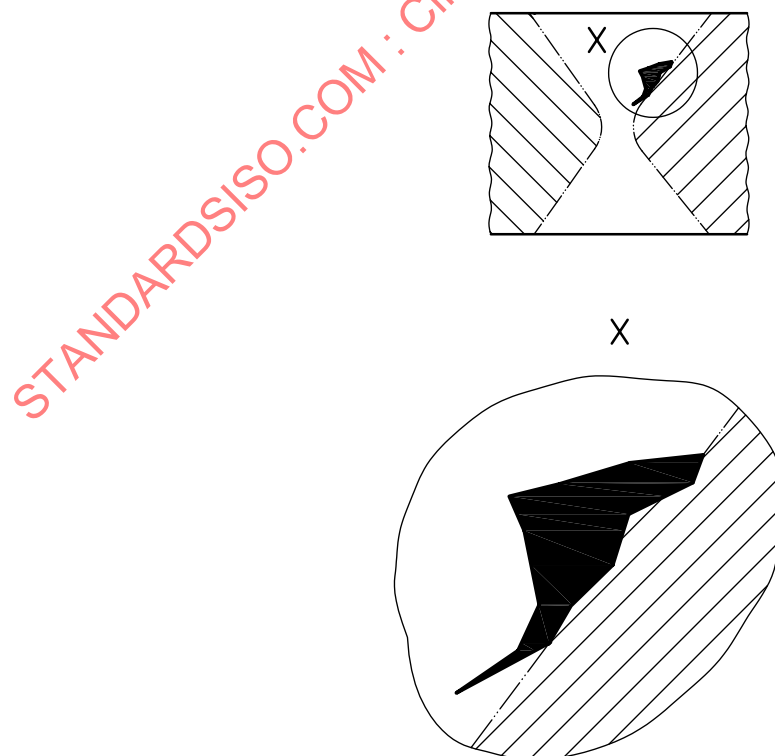
The angles at which the ultrasonic beam is incident upon the indication shall have a difference of at least 10° . The comparison shall be made upon the same area of the indication.

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

Stage 5: If the echodynamic pattern does not match pattern 3, the indication is classified as non-planar.

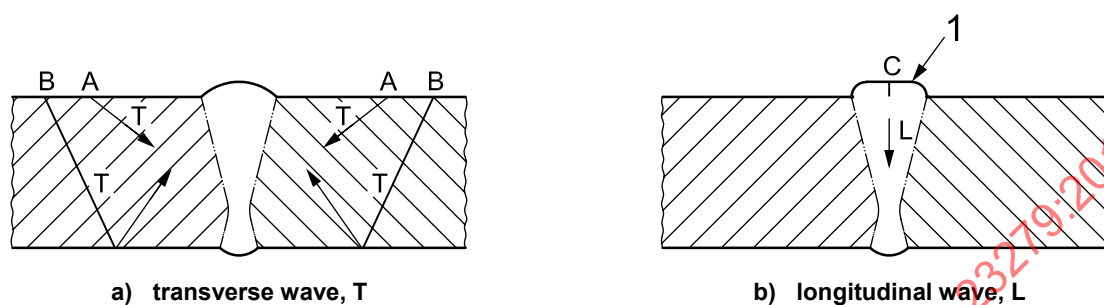
The echo patterns are those defined in Annex C.

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

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

Annex B (informative)

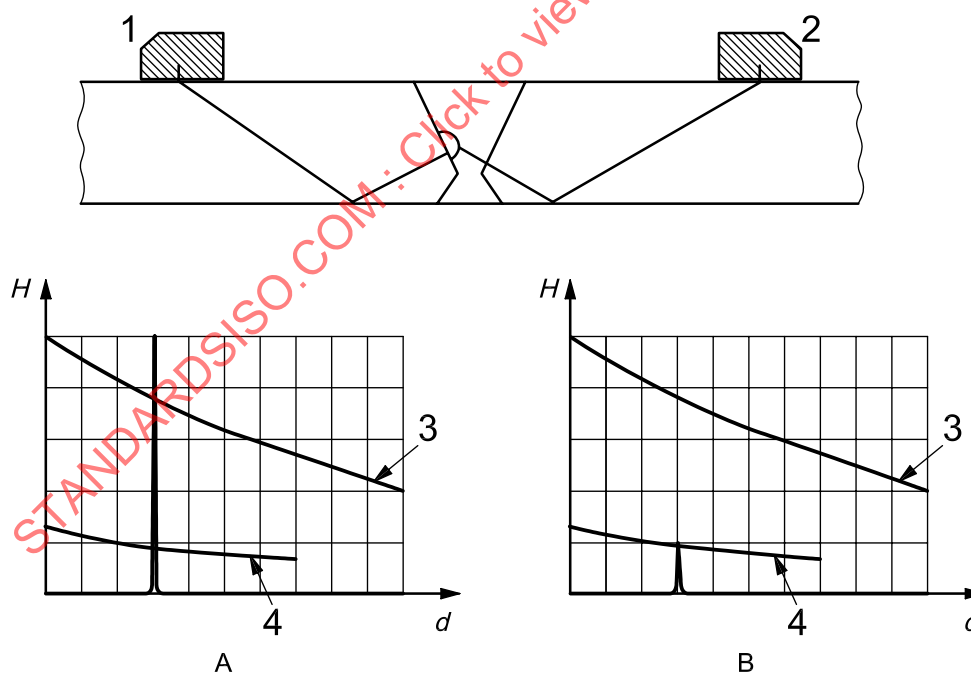
Directional reflectivity



Key

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

Figure B.1 — Examples of directions of examination



Key

- 1 position 1
- 2 position 2
- 3 reference level
- 4 reference level minus 9 dB
- d sound path
- H amplitude

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

Annex C (informative)

Basic echodynamic 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, this rises in amplitude smoothly to a single maximum before falling smoothly to noise level.

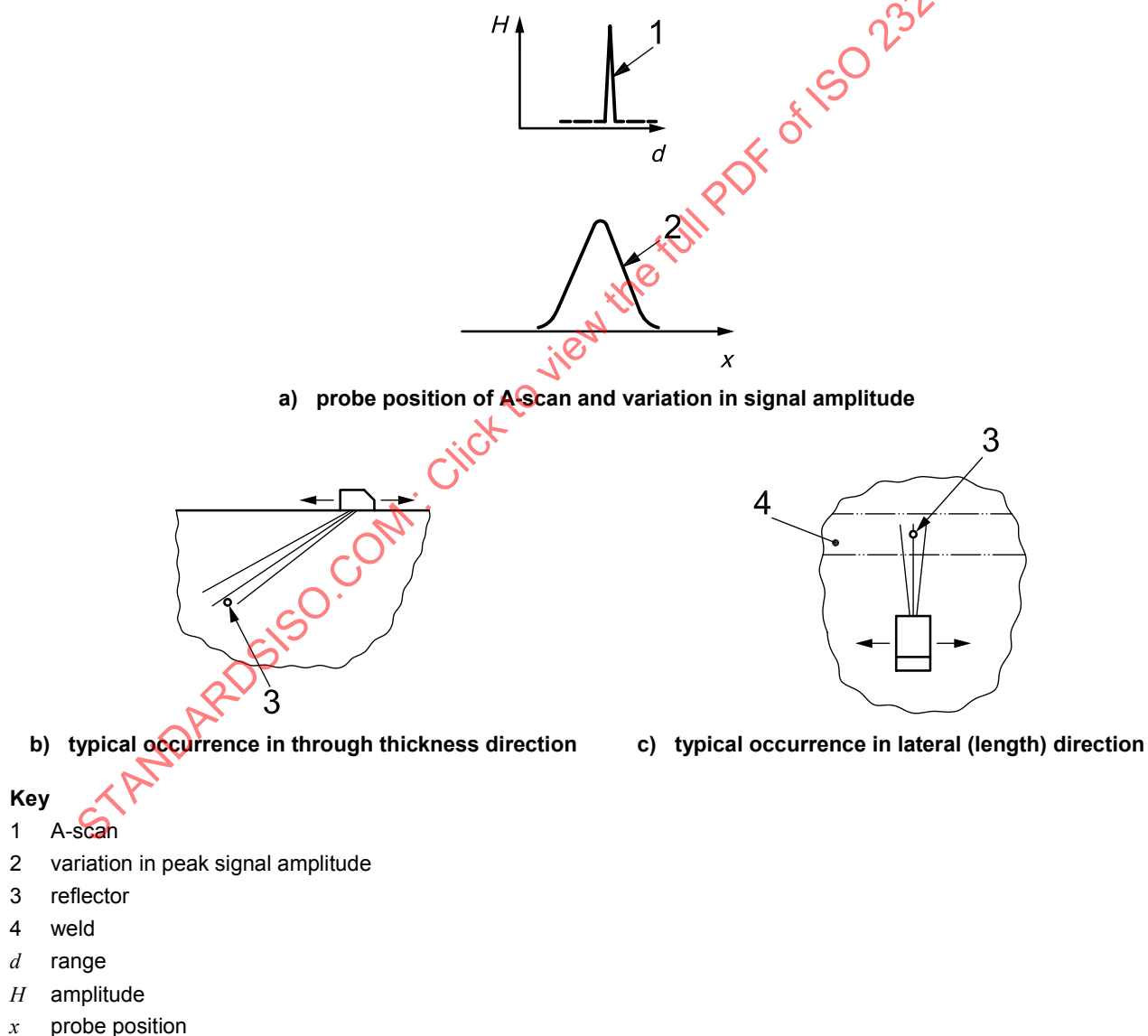
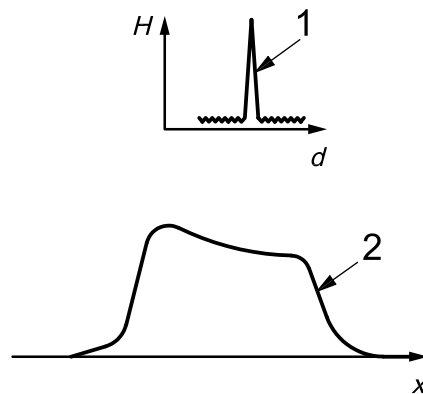


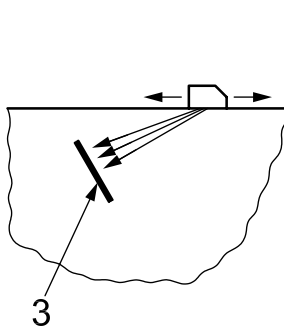
Figure C.1 — Pattern 1 ultrasonic response

C.2 Pattern 2

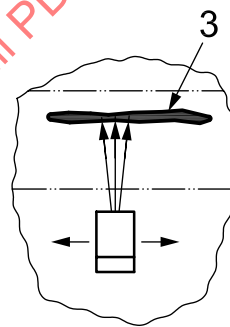
An extended smooth reflector response is shown in Figure C.2. At any probe position, the A-scan shows a single sharp echo. When the ultrasonic beam is moved over the reflector, the echo rises smoothly to a plateau and is maintained, with minor variations in amplitude of up to 4 dB, until the beam moves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

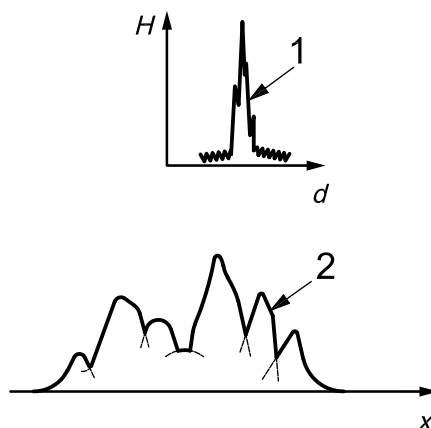
- 1 A-scan
- 2 variation in peak signal amplitude
- 3 reflector
- d range
- H amplitude
- x probe position

Figure C.2 — Pattern 2 ultrasonic response

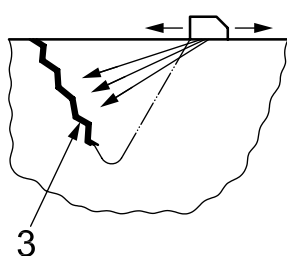
C.3 Pattern 3

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

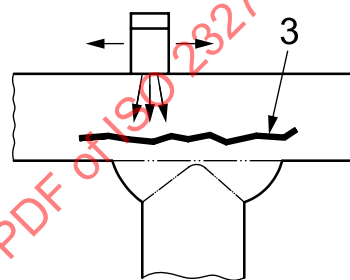
One variant, at near normal incidence, is shown in Figure C.3. At any probe position, the A-scan shows a single but ragged echo. As the probe is moved, this may undergo large (greater than ± 6 dB) random fluctuations in amplitude. The fluctuations are caused by reflection from different facets of the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



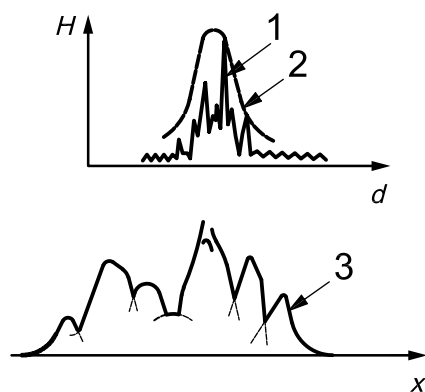
c) typical occurrence in lateral (length) direction

Key

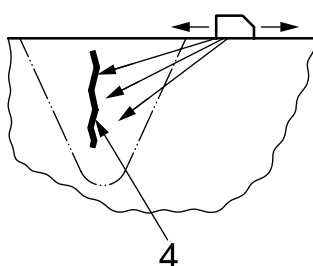
- 1 A-scan
- 2 variation in peak signal amplitude
- 3 reflector
- d range
- H amplitude
- x probe position

Figure C.3 — Pattern 3 ultrasonic response**C.4 Pattern 4**

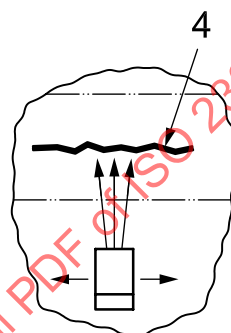
The second variant of an extended rough reflector response, oblique incidence, “travelling echo pattern”, is shown in Figure C.4. At any probe position the A-scan shows an extended train of signals (“subsidiary peaks”) within a bell-shaped pulse envelope. As the probe is moved, each subsidiary peak travels 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 peak signal amplitude
- 4 reflector
- d range
- H amplitude
- x probe position

Figure C.4 — Pattern 4 ultrasonic response