INTERNATIONAL STANDARD

ISO 5577

Second edition
2017-02

Non-destructive testing — Ultrasonic testing — Vocabulary

Essais non destructif — Contrôle par ultrasons — Vocabulaire

Reference number
ISO 5577:2017(E)

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Foreword

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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).

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ISO 5577 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 138, *Non-destructive testing*, in collaboration with ISO Technical Committee TC 135, *Non-destructive testing*, Subcommittee SC 3, *Ultrasonic testing*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 5577:2000), which has been technically revised with changes to terms and definitions and structure.

Non-destructive testing — Ultrasonic testing — Vocabulary

1 Scope

This document defines the terms used in ultrasonic non-destructive testing and forms a common basis for standards and general use. This document does not cover terms used in ultrasonic testing with phased arrays.

NOTE Terms for phased array ultrasonic testing are defined in EN 16018.

2 Normative references

There are no normative references in this document.

3 Terms related to frequencies, waves and pulses

For the purposes of this document, the terms and definitions given in this clause and those given in Clauses 4, 5 and 6 for sound, test equipment and ultrasonic testing apply.

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

3.1 Frequencies

3.1.1
frequency
number of cycles per second

Note 1 to entry: Expressed in Hertz (Hz).

3.1.2
nominal frequency
probe frequency
frequency (3.1.1) of the *probe* (5.2.1) as stated by the manufacturer

3.1.3
test frequency
effective ultrasonic frequency of a system used to test a material or object

3.1.4
frequency spectrum
distribution of *amplitude* (3.2.2) in relation to *frequency* (3.1.1)

Note 1 to entry: See Figure 1.

3.1.5
centre frequency
arithmetic mean of the cut-off frequencies

Note 1 to entry: See Figure 1.

3.1.6
peak frequency
frequency (3.1.1) at which the maximum amplitude is observed

Note 1 to entry: See Figure 1.

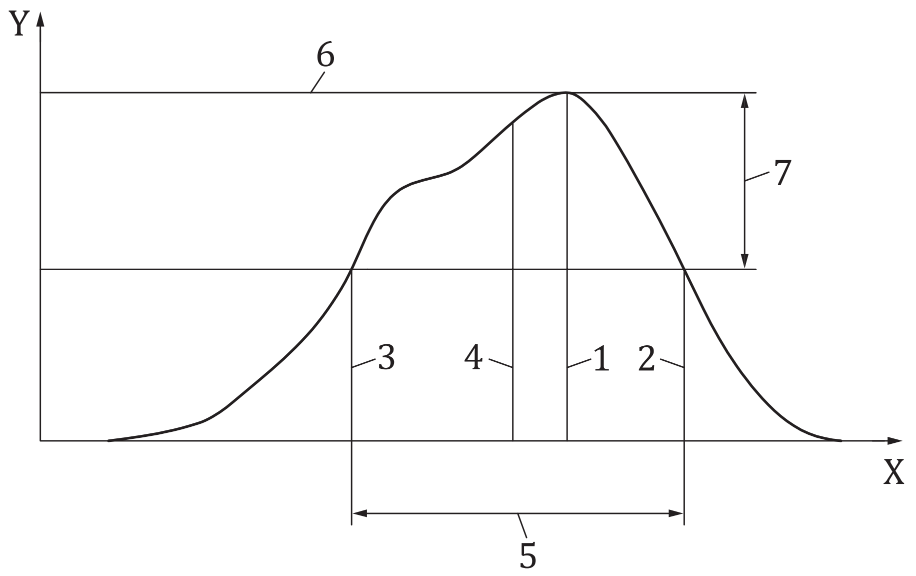
3.1.7
cut-off frequency
frequency (3.1.1) at which the *amplitude* (3.2.2) of transmitted signal has dropped by a specified amount from the amplitude at *peak frequency* (3.1.6), for example, by 3 dB

Note 1 to entry: See Figure 1.

3.1.8
bandwidth
width of the *frequency spectrum* (3.1.4) between the upper and lower cut-off frequency

Note 1 to entry: See Figure 1.

3.1.9
relative bandwidth
ratio of the *bandwidth* (3.1.8) to the *centre frequency* (3.1.5), in per cent



Key

X	frequency	4	centre frequency
Y	amplitude	5	bandwidth at specified amplitude drop
1	peak frequency	6	peak amplitude
2	upper cut-off frequency	7	specified amplitude drop
3	lower cut-off frequency		

Figure 1 — Terms related to frequency and bandwidth

3.2 Waves and pulses

3.2.1
ultrasonic wave
any acoustic wave having a *frequency* (3.1.1) higher than the audible range of the human ear, generally taken as higher than 20 kHz

3.2.2
amplitude
absolute or relative measure of a sound wave's magnitude

3.2.3
phase
momentary condition of a vibration expressed as an arc measurement or an angle

3.2.4
wavelength
distance between consecutive corresponding points of the same *phase* (3.2.3)

Note 1 to entry: See Figure 2.

3.2.5
wavefront
continuous surface joining all the most forward points of a wave that have the same *phase* (3.2.3)

3.2.6
time-of-flight
TOF
time it takes an ultrasonic pulse to travel from the transmitter probe through the test object to the receiver probe

3.2.7
pulse
electrical or ultrasonic signal of short duration

3.2.8
pulse amplitude
maximum amplitude of a *pulse* (3.2.7) (peak-to-peak)

Note 1 to entry: For rectified pulses (A-scan), baseline-to-peak.

3.2.9
pulse rise time
time taken for a *pulse amplitude* (3.2.8) to change between two defined levels

3.2.10
pulse duration
time interval between the leading and trailing edges of a *pulse* (3.2.7) measured at a defined level below the peak amplitude

3.2.11
pulse shape
diagramatic representation of the *amplitude* (3.2.2) of a *pulse* (3.2.7) as a function of time

3.2.12
pulse envelope
contour of a *pulse shape* (3.2.11) including all the peaks in terms of *amplitude* (3.2.2) and time

3.2.13
pulse energy
total energy within a *pulse* (3.2.7)

3.2.14
pulse reverberation
undesirable vibration at the beginning and end of a *pulse* (3.2.7) above a defined level

3.2.15
broad-band pulse
pulse (3.2.7) in which the *relative bandwidth* (3.1.9) is ≥65 %

3.2.16
medium-band pulse
pulse (3.2.7) in which the *relative bandwidth* (3.1.9) is >35 % and <65 %

3.2.17
narrow-band pulse
pulse (3.2.7) in which the *relative bandwidth* (3.1.9) is ≤35 %

3.2.18
pulse repetition frequency
PRF
number of *pulses* (3.2.7) generated per second, expressed in Hertz (Hz)

3.3 Types of waves

3.3.1
longitudinal wave
compressional wave
wave in which the direction of displacement of particles is in the same direction as the propagation of the wave

Note 1 to entry: See Figure 2 a).

3.3.2
transverse wave
shear wave
wave in which the direction of displacement of particles is perpendicular to the direction of the propagation of the wave

Note 1 to entry: See Figure 2 b).

3.3.3
surface wave
Rayleigh wave
wave which propagates on the surface of a material with an effective penetration depth of less than one *wavelength* (3.2.4)

3.3.4
creeping wave
wave generated at the first *critical angle* (4.4.11) of incidence and propagated along the surface as a *longitudinal wave* (3.3.1)

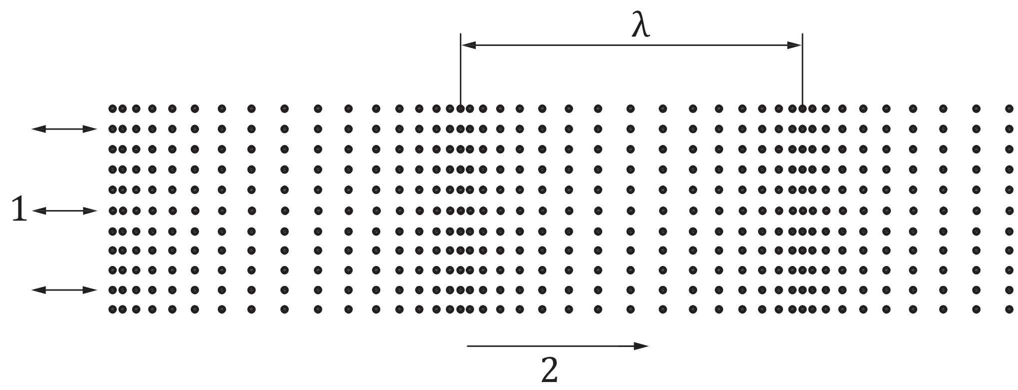
Note 1 to entry: It is not influenced by the test object's surface conditions, nor does the beam follow undulations on the surface.

3.3.5
plate wave
Lamb wave
wave which propagates within the whole thickness of a plate and which can only be generated at particular values of angle of incidence, *frequency* (3.1.1) and plate thickness

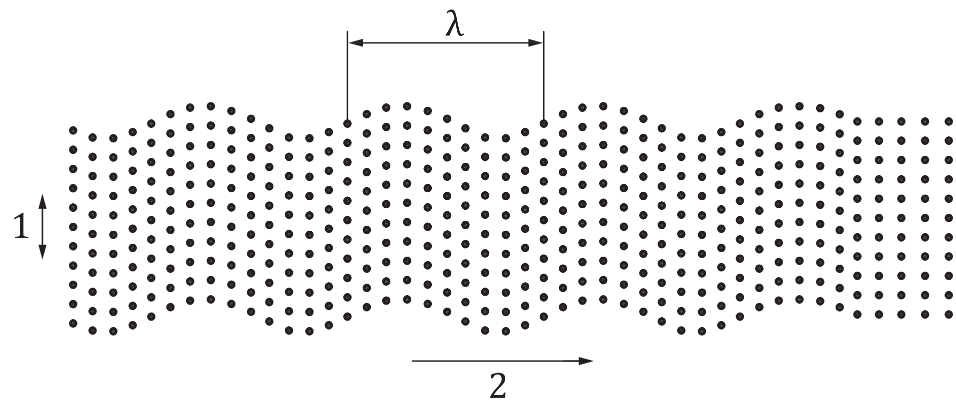
3.3.6
plane wave
wave with a planar wave front

3.3.7
cylindrical wave
wave with a cylindrical wave front

3.3.8
spherical wave
wave with a spherical wave front



a) Longitudinal wave; compressional wave



b) Transverse wave; shear wave

Key

1 direction of oscillation

2 direction of propagation

λ wavelength

Figure 2 — Types of waves

4 Terms related to sound

4.1 Sound generation and reception

4.1.1
transducer
active element of a *probe* (5.2.1) which converts electrical energy into sound energy and vice versa

4.1.2
piezo-electric transducer
transducer (4.1.1) made from piezo-electric material

4.1.3
composite transducer
plate consisting of piezo-electric ceramic rods embedded in a polymer matrix

4.1.4
electro-magnetic acoustic transducer
EMAT
transducer (4.1.1) which uses magnetostriction or Lorentz force to generate ultrasound in paramagnetic materials

4.1.5
focusing transducer
piezo-electric transducer (4.1.2) having at least one curved surface, used for focusing the sound beam (4.2.2)

4.2 Sound propagation

4.2.1
sound field
three-dimensional pressure distribution produced by transmitted sound energy

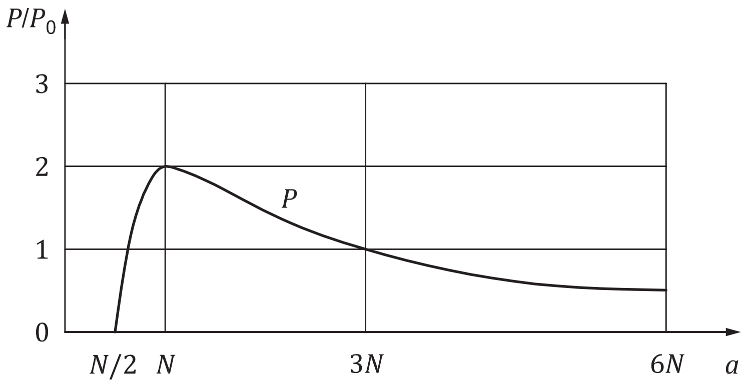
4.2.2
sound beam
ultrasonic beam
part of the *sound field* (4.2.1) within which the major part of the ultrasonic energy is transmitted

4.2.3
beam axis
line through the points of maximum sound pressure at different distances

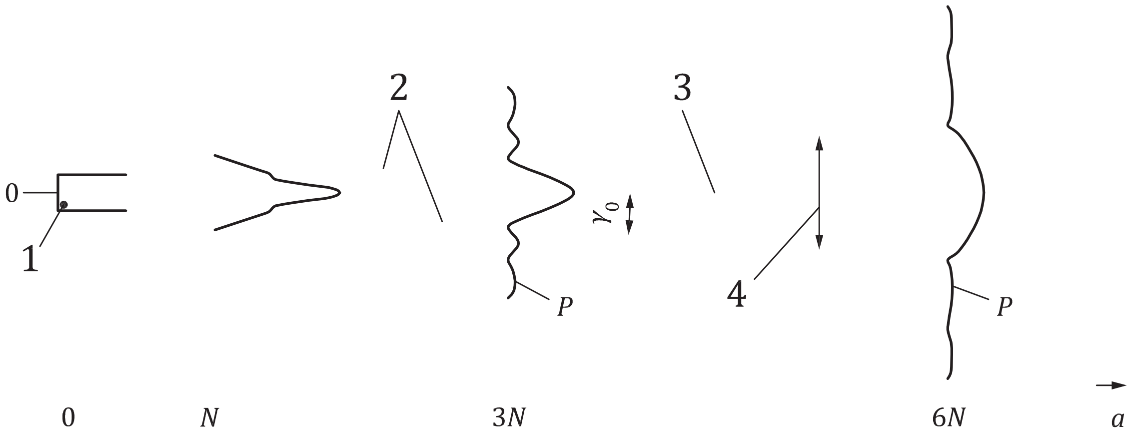
Note 1 to entry: See Figures 3 b), 8, 9, 10 and 11.

4.2.4
beam profile
curve which shows the signal amplitude along the *beam axis* (4.2.3) or perpendicular to the beam axis at a defined distance from the *probe* (5.2.1)

Note 1 to entry: See Figure 3.



a) Profile along the beam axis



b) Profiles perpendicular to the beam axis

Key

1	transducer	γ_0	angle of divergence (drop to zero)
2	beam boundary	a	distance
3	beam axis	N	near-field length
4	beam width at a given distance	P	sound pressure

Figure 3 — Beam profiles

4.2.5
beam boundary
boundary of the ultrasonic beam where the sound pressure has fallen to a given fraction of the value on the *beam axis* (4.2.3), measured at the same distance from the *probe* (5.2.1)

Note 1 to entry: See Figures 3 b), 8, 9 and 11.

4.2.6
beam width
dimension of the beam perpendicular to the *beam axis* (4.2.3) measured between the beam boundaries at a defined distance from the *probe* (5.2.1)

Note 1 to entry: See Figure 3 b).

4.2.7
angle of divergence
angle within the *far-field* (4.2.11) between the *beam axis* (4.2.3) and the *beam boundary* (4.2.5)

Note 1 to entry: See Figures 3 b), 8 and 11.

4.2.8
near-field
Fresnel zone
zone of the *sound beam* (4.2.2) where sound pressure does not change monotonically with distance because of interference

Note 1 to entry: See Figure 8.

4.2.9
near-field point
position on the *beam axis* (4.2.3) where the sound pressure reaches a final maximum

4.2.10
near-field length
distance between the *transducer* (4.1.1) and the *near-field point* (4.2.9)

Note 1 to entry: See Figure 3.

4.2.11
far-field
zone of the *sound beam* (4.2.2) that extends beyond the *near-field point* (4.2.9)

Note 1 to entry: See Figures 8 and 11.

4.2.12
focal point
focus
point where the sound pressure on the *beam axis* (4.2.3) is at its maximum

4.2.13
focal distance
focal length
distance from the *probe* (5.2.1) to the *focal point* (4.2.12)

Note 1 to entry: See Figures 8 and 11.

4.2.14
focal zone
focal range
zone in *sound beam* (4.2.2) of a *probe* (5.2.1) in which the sound pressure remains above a defined level related to its maximum

4.2.15
length of the focal zone
distance along the *beam axis* (4.2.3) from the start to the end of the *focal zone* (4.2.14)

4.2.16
width of the focal zone
dimension of the *focal zone* (4.2.14) at *focal distance* (4.2.13) perpendicular to the *beam axis* (4.2.3)

4.2.17
acoustical properties
characteristic parameters of a material which control the propagation of sound in the material

4.2.18
acoustically anisotropic material
material which has differing sound velocities in differing directions of propagation

4.2.19
sound velocity
velocity of propagation
phase velocity (4.2.20) or *group velocity* (4.2.21) of a sound wave in a material in the direction of propagation

Note 1 to entry: In a non-dispersive material, there is no difference between phase and group velocity.

Note 2 to entry: In an anisotropic material, the velocities may depend on the direction of propagation.

4.2.20
phase velocity
velocity of propagation(4.2.19) of a wave front

4.2.21
group velocity
velocity of propagation (4.2.19) of the acoustic energy

4.3 Loss of sound pressure

4.3.1
attenuation
sound attenuation
decrease of sound pressure when a wave travels through a material, arising from *absorption* (4.3.4) and *scattering* (4.3.3)

4.3.2
attenuation coefficient
coefficient used to express *attenuation* (4.3.1) per unit of distance travelled, dependent on material properties, *wavelength* (3.2.4) and wave type

Note 1 to entry: The attenuation coefficient is usually expressed in dB/m.

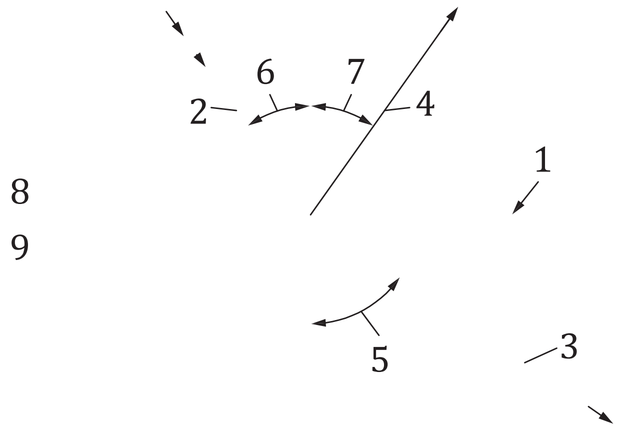
4.3.3
scattering
random reflections caused by grain structure and/or by small *reflectors* (6.4.1) in the beam path

4.3.4
absorption
part of the *attenuation* (4.3.1) resulting from transformation of ultrasonic energy into other types of energy, for example, thermal energy

4.4 Sound waves at interfaces

4.4.1
interface
boundary between two materials, in acoustic contact, having different acoustic properties

Note 1 to entry: See Figure 4.



Key

1 interface
2 direction of incident wave
3 direction of refracted wave
4 direction of reflected wave
5 angle of refraction
6 angle of incidence
7 angle of reflection
8 medium 1
9 medium 2

Figure 4 — Refraction and reflection of waves

4.4.2
angle of incidence
angle between the direction of the incident wave and the normal to the *interface* (4.4.1)

Note 1 to entry: See Figure 4.

4.4.3
reflection
change of the direction of sound propagation within the same material when impinging on an *interface* (4.4.1)

Note 1 to entry: See Figure 4.

4.4.4
refraction
change of the direction of sound propagation when passing obliquely through the *interface* (4.4.1) between two materials of differing sound velocities

Note 1 to entry: See Figure 4.

4.4.5
angle of reflection
angle between the direction of the reflected wave and the normal to the *interface* (4.4.1)

Note 1 to entry: See Figure 4.

4.4.6
angle of refraction
angle between the direction of the refracted wave and the normal to the *interface* (4.4.1)

Note 1 to entry: See Figure 4.

4.4.7
acoustical impedance
ratio of sound pressure to particle displacement velocity

Note 1 to entry: In a material with perfect elastic properties for a plane longitudinal wave, it is equal to the product of *sound velocity* (4.2.19) and density.

4.4.8
reflection coefficient
ratio of reflected sound pressure to incident sound pressure at a reflecting surface

Note 1 to entry: The corresponding transmission coefficient is defined in 4.4.9.

4.4.9
transmission coefficient
ratio of sound pressure transmitted through an *interface* (4.4.1) to the incident sound pressure

Note 1 to entry: The corresponding reflection coefficient is defined in 4.4.8.

4.4.10
refractive index
ratio of the sound velocities of two materials in contact

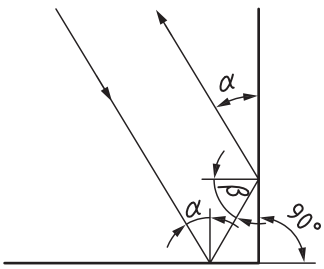
4.4.11
critical angle
angle of incidence (4.4.2) at which the *angle of refraction* (4.4.6) is 90° for a defined wave type

Note 1 to entry: For *longitudinal* (3.3.1) and *transverse waves* (3.3.2), there are two different critical angles.

4.4.12
total reflection
reflection (4.4.3) which occurs when the *angle of incidence* (4.4.2) is greater than the *critical angles* (4.4.11) or if the *reflection coefficient* (4.4.8) is unity

4.4.13
corner reflection
reflection (4.4.3) of *ultrasonic waves* (3.2.1) in a corner formed by two or three coincident, mutually perpendicular surfaces

Note 1 to entry: See Figure 5.



Key
α and β angles of incidence

Figure 5 — Corner reflection

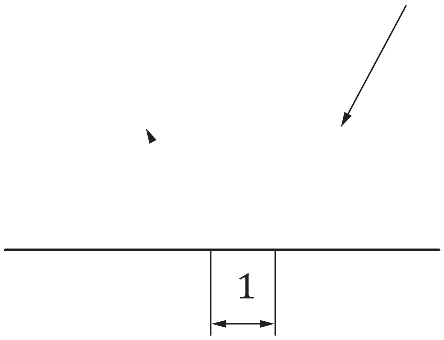
4.4.14
wave mode conversion
change of wave mode to another by *refraction* (4.4.4) or *reflection* (4.4.3)

4.4.15
edge effect
phenomenon resulting from the diffraction of an *ultrasonic wave* (3.2.1) by the edges of a *reflector* (6.4.1)

4.4.16
beam displacement
displacement of the beam due to *reflection* (4.4.3) from a surface of a solid

Note 1 to entry: It mainly depends on *frequency* (3.1.1) and angle.

Note 2 to entry: See Figure 6.



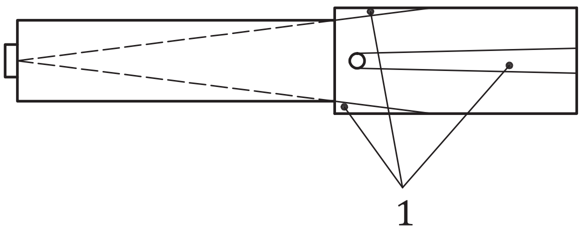
Key

1 beam displacement due to reflection

Figure 6 — Beam displacement

4.4.17
acoustic shadow
region in an object which cannot be reached by *ultrasonic waves* (3.2.1) travelling in a given direction because of the geometry of the object or a discontinuity in it

Note 1 to entry: See Figure 7.



Key

1 acoustic shadow

Figure 7 — Acoustic shadow

5 Terms related to test equipment

5.1 Instrument

5.1.1
ultrasonic instrument
instrument used together with the *probe* or *probes* (5.2.1), which transmits, receives, processes and displays ultrasonic signals for non-destructive testing purposes

5.1.2
transmitter
electrical device which generates the *transmitter pulses* (5.1.3)

5.1.3
transmitter pulse
electrical pulse generated by the *ultrasonic instrument* (5.1.1) for exciting the *transducer* (4.1.1)

5.1.4
receiver
electrical device which amplifies or converts signals coming from the ultrasonic probe into usable signals

5.1.5
amplifier
electronic device which converts a small signal to a larger signal

Note 1 to entry: This can be a linear amplifier using a linear law or a logarithmic amplifier using a logarithmic law.

5.1.6
attenuator
electronic device which reduces the *amplitude* (3.2.2) or power of a signal without distortion

5.1.7
gain
level of amplification of signals

Note 1 to entry: Usually expressed in decibels (dB).

5.1.8
gain control
instrument control with which a signal may be adjusted to a given height

5.1.9
dynamic range
ratio of the *amplitudes* (3.2.2) of the largest and smallest signal which an *ultrasonic instrument* (5.1.1) can display without distortion

Note 1 to entry: Dynamic range is usually expressed in decibels (dB).

5.1.10
linearity of amplitude
vertical linearity
proportionality of the amplitude of signals on the vertical scale of the ultrasonic instrument's display

5.1.11
suppression
reduction of noise indications by eliminating all *indications* (6.5.14) below a predetermined amplitude level (threshold value)

5.1.12
time-corrected gain
TCG
distance–amplitude compensation
function of a device which changes the amplification of *echoes* (6.5.1) from *reflectors* (6.4.1) of equal size, but different distances and results in equal height of the echoes on the display

Note 1 to entry: This term shall not be confused with *distance–amplitude curve (DAC)* (6.8.15).

Note 2 to entry: This definition of *time-corrected gain* differs from the definition of the same term given by 6.8.16.

5.1.13
analogue-to-digital converter
device which converts analogue signals into discrete numbers representing the pattern of the signal

5.1.14
digitization error
inaccuracy introduced as a result of analogue-to-digital conversion

5.1.15
time base
abscissa of an A-scan calibrated in time or distance

Note 1 to entry: See Figure 20.

5.1.16
time base control
instrument control which is used to adjust the *time base* (5.1.15) to a required range

5.1.17
time base range
maximum ultrasonic path length that is displayed on a particular *time base* (5.1.15)

5.1.18
delayed time base sweep
time base sweep triggered with a given delay, fixed or adjustable, in relation to the *transmitter pulse* (5.1.3) or a *reference echo* (5.4.4)

5.1.19
linearity of time base
horizontal linearity
proportionality of the positions of signals on the *time base* (5.1.15) of the ultrasonic instrument's display

5.1.20
monitor
component of an *ultrasonic instrument* (5.1.1) which provides a *gate* (5.1.21) within which the presence of *echoes* (6.5.1) above or below a defined level can be indicated

5.1.21
gate
time gate
window
electronic means of selecting a segment of the *time base* (5.1.15) for monitoring or further processing of signals

5.1.22
gate threshold
monitor level
defined amplitude level (threshold) above or below which echoes (see 6.5.1) signals in a *gate* (5.1.21) are selected for further processing

5.1.23
proportional gate
gate (5.1.21) which provides a proportional output of any signal that is received during the period of the gate

Note 1 to entry: The output can be voltage or current.

5.2 Probes

5.2.1
probe
electro-acoustical device, usually incorporating one or more *transducers* (4.1.1), and possibly a *delay line* (5.2.7) intended for transmission and/or reception of *ultrasonic waves* (3.2.1)

5.2.2
single-transducer probe
probe (5.2.1) with a single *transducer* (4.1.1) for the transmission and reception of *ultrasonic waves* (3.2.1)

5.2.3
multi-transducer probe
probe (5.2.1) with several separated *transducers* (4.1.1), which through switching permits the creation of certain *sound beam* (4.2.2) configurations

5.2.4
transducer backing
material coupled to the rear surface of a *transducer* (4.1.1) to damp the transducer oscillation

Note 1 to entry: See Figures 8, 9 and 11.

5.2.5
probe shoe
shaped piece of material which is interposed between the *probe* (5.2.1) and the test object for the purpose of improving the coupling and/or protecting the probe

5.2.6
protection layer
layer of protective material forming an integral part of the *probe* (5.2.1) and separating the *transducer* (4.1.1) from direct contact with the test object

Note 1 to entry: See Figure 8.

5.2.7
delay line
delay block
component introduced to create the *delay path* (5.2.8)

5.2.8
delay path
path on the *beam axis* (4.2.3) between *transducer* (4.1.1) and point of entry into the test object

5.2.9
nominal transducer size
physical size of the *transducer* (4.1.1)

5.2.10
effective transducer size
reduced area of the physical size of the *transducer* (4.1.1)

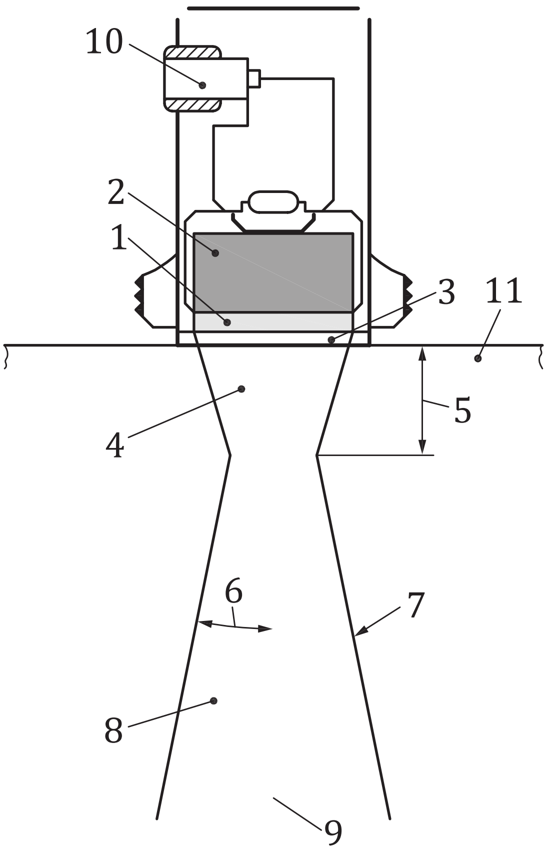
Note 1 to entry: The effective transducer size is determined from the measured *focal distance* (4.2.13), *frequency* (3.1.1), *sound velocity* (4.2.19) and, for *angle-beam probes* (5.2.13), the measured *beam angle* (5.2.15).

5.2.11
wedge
wedge-shaped component usually made of plastic material which causes an *ultrasonic wave* (3.2.1) to be refracted into the test object at a defined angle

Note 1 to entry: See Figure 9.

5.2.12
straight-beam probe
normal-beam probe
probe (5.2.1) whose *beam axis* (4.2.3) is perpendicular to the contact surface

Note 1 to entry: See Figure 8.



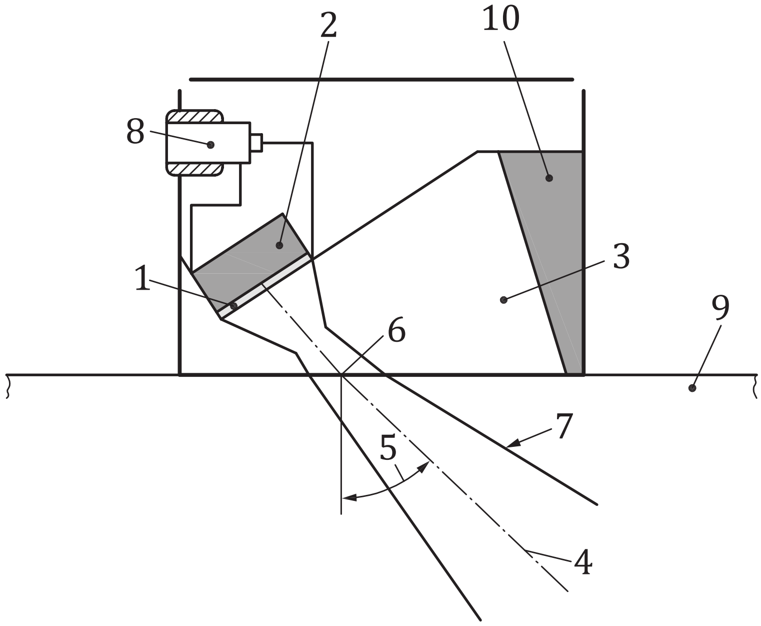
Key

1	transducer
2	transducer backing
3	protection layer
4	near-field
5	focal distance
6	angle of divergence
7	beam boundary
8	far-field
9	beam axis
10	connector
11	test object

Figure 8 — Straight-beam probe

5.2.13
angle-beam probe
probe (5.2.1) generating a beam at an angle other than normal to the *test surface* (6.2.1)

Note 1 to entry: See Figure 9.



Key

1 transducer
2 transducer backing
3 wedge
4 beam axis
5 beam angle
6 probe index point
7 beam boundary
8 connector
9 test object
10 damping material

Figure 9 — Angle-beam probe

5.2.14
variable-angle-beam probe
probe (5.2.1) generating a beam at angles that can be changed

5.2.15
beam angle
angle between the *beam axis* (4.2.3) and the normal to the *interface* (4.4.1) for a particular *probe* (5.2.1)

Note 1 to entry: See Figure 9.

5.2.16
probe index point
intersection point of the sound beam axis with the probe contact surface

Note 1 to entry: See Figures 9 and 15.

Note 2 to entry: The projection of the probe index point may be marked on the housing of an *angle-beam probe* (5.2.13).

5.2.17
nominal probe angle
quoted value of the refraction angle of a *probe* (5.2.1) for a given material and temperature

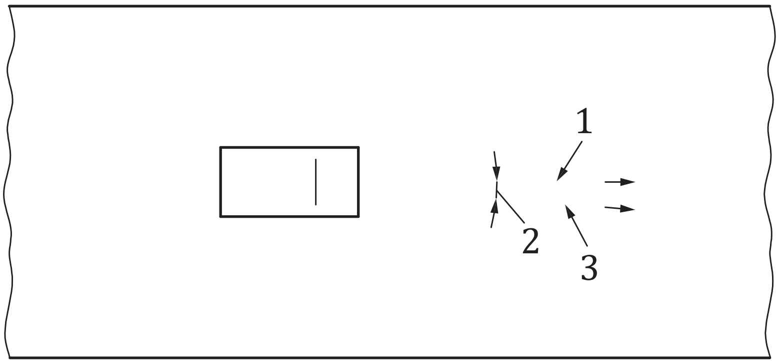
5.2.18
probe axis
geometrical reference axis through the *probe* (5.2.1), serving as the origin for angular coordinates used in describing the directional characteristics of a probe

Note 1 to entry: See Figure 10.

Note 2 to entry: For *straight-beam probes* (5.2.12), the probe axis is perpendicular to the *test surface* (6.2.1). *For angle-beam probes* (5.2.13), the probe axis is projected onto the test surface.

5.2.19
squint angle
angle between the *probe axis* (5.2.18) and the projection of the *beam axis* (4.2.3) on the *test surface* (6.2.1)

Note 1 to entry: See Figure 10.



Key

1 probe axis

2 squint angle

3 beam axis

Figure 10 — Squint angle

5.2.20
longitudinal wave probe
compression wave probe
probe (5.2.1) generating and/or receiving *longitudinal waves* (3.3.1)

5.2.21
transverse wave probe
shear wave probe
probe (5.2.1) generating and/or receiving *transverse waves* (3.3.2) usually via *wave mode conversion* (4.4.14) by *refraction* (4.4.4)

5.2.22
surface wave probe
probe (5.2.1) generating and/or receiving *surface waves* (3.3.3)

5.2.23
contoured probe
probe (5.2.1) having a contact surface which is shaped to fit the curved surface of an object

5.2.24
focusing probe
probe (5.2.1) which concentrates the *sound beam* (4.2.2) by special devices, by curved transducer, lens or electronic mean, to generate a focused beam

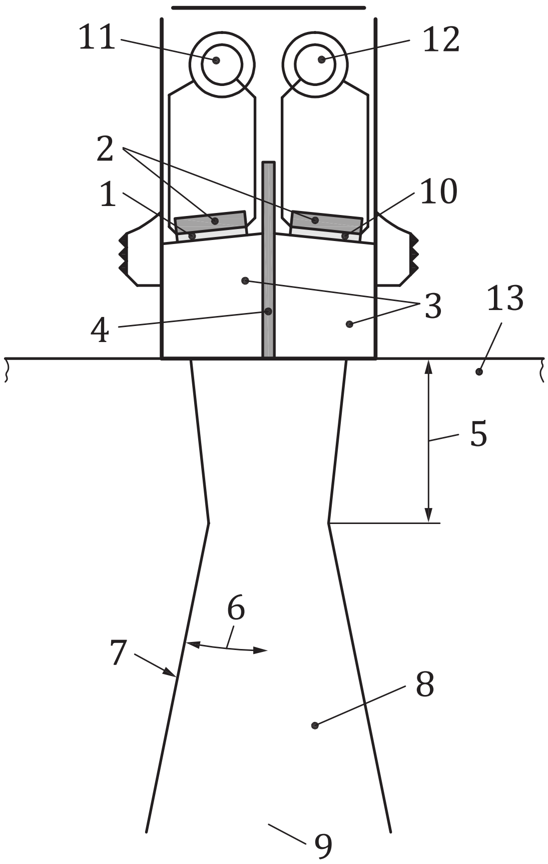
5.2.25
cross talk
signal interference across an intended acoustic or electric barrier

Note 1 to entry: An example of electrical cross talk is that between adjacent transmit and receive channels of an *ultrasonic instrument* (5.1.1).

Note 2 to entry: An example of acoustical cross talk is that between *probes* (5.2.1) or between *transducers* (4.1.1) [*dual-transducer probe* (5.2.26)].

5.2.26
dual-transducer probe
dual-element probe
probe (5.2.1) in which the transmit and receive *transducers* (4.1.1) are separate and are electrically and acoustically isolated from each other

Note 1 to entry: See Figure 11.



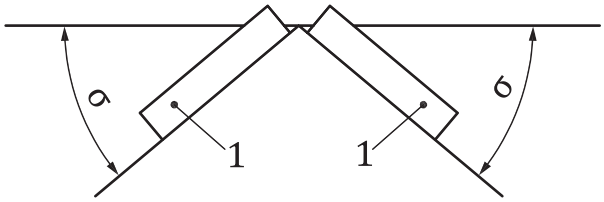
Key

1	transmitting transducer	8	far-field
2	transducer backing	9	beam axis
3	delay block	10	receiving transducer
4	acoustic barrier	11	transmitting connector
5	focal distance	12	receiving connector
6	angle of divergence	13	test object
7	beam boundary		

Figure 11 — Dual-transducer probe

5.2.27
roof angle
for *dual-transducer probes* (5.2.26), this angle indicates a difference in orientation of the transducer planes

Note 1 to entry: See Figure 12.



Key

1 transducer

σ roof angle

Figure 12 — Dual-transducer probe with roof angles

5.2.28
convergence zone
zone at the intersection of the transmitting and receiving beams of a *dual-transducer probe* (5.2.26)

5.2.29
immersion probe
probe (5.2.1) generating and/or receiving *longitudinal waves* (3.3.1) to be used in a liquid

5.2.30
wheel probe
probe (5.2.1) generating and/or receiving *ultrasonic waves* (3.2.1) incorporating one or more *transducers* (4.1.1) mounted inside a liquid-filled flexible tyre

5.3 Combined equipment

5.3.1
test equipment
equipment consisting of an *ultrasonic instrument* (5.1.1), *probes* (5.2.1), cables and all devices connected to the instrument during testing

5.3.2
ultrasonic test system
UT system
electro-mechanical system which allows ultrasonic testing of an object

5.3.3
dead zone
zone directly under the coupling surface in which discontinuities are undetectable

Note 1 to entry: The depth of the zone is dependent on various factors, e.g. *probe* (5.2.1), instrument setting, test object material.

5.3.4
detection sensitivity
characteristic of an *ultrasonic test system* (5.3.2) defined by the smallest detectable *reflector* (6.4.1)

5.3.5
lateral resolution
capability of an *ultrasonic test system* (5.3.2) to resolve two separate targets at the same distance

5.3.6
axial resolution
capability of an *ultrasonic test system* (5.3.2) to resolve two separate targets at different distances

5.4 Calibration, reference and test blocks

5.4.1
calibration block
piece of material of specified composition, surface finish, heat treatment and geometric form, by means of which ultrasonic *test equipment* (5.3.1) can be assessed and calibrated

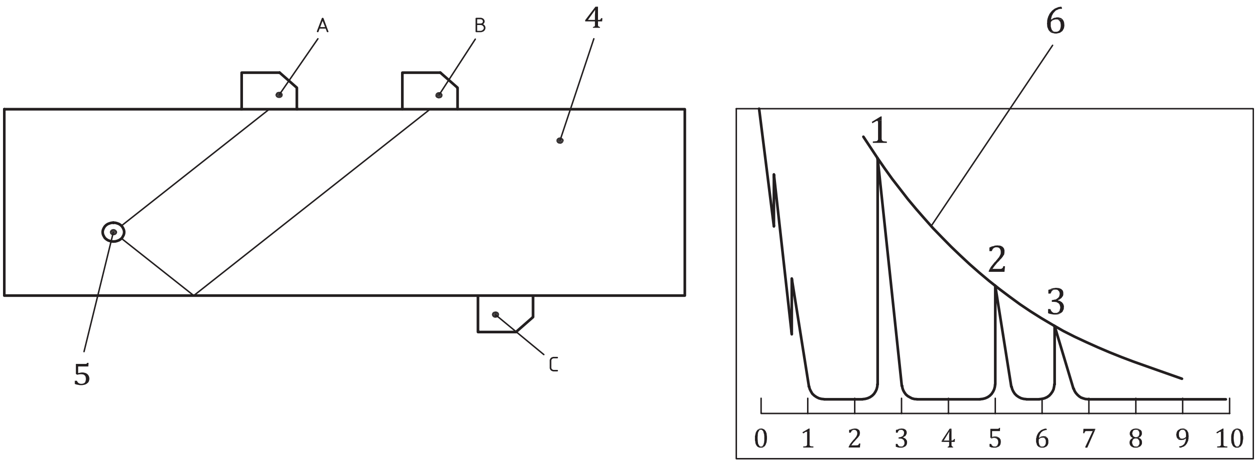
Note 1 to entry: For example, see ISO 2400, ISO 7963 and ISO 16946.

5.4.2
reference block
block of material representative of the material to be tested with similar acoustic properties containing well-defined *reflectors* (6.4.1), used to adjust the sensitivity and/or *time base* (5.1.15) of the *ultrasonic instrument* (5.1.1) in order to compare detected discontinuity indications with those arising from the known reflectors (6.4.1)

5.4.3
test block
defined piece of material which allows tests for the accuracy and/or performance of an *ultrasonic test system* (5.3.2)

5.4.4
reference echo
echo (6.5.1) from a prescribed *reference reflector* (6.4.2)

Note 1 to entry: Example shown in Figure 13.



a) Generation of reference echoes **b) Display of the reference echoes and the DAC**

Key

1 reference echo from position A (direct)
2 reference echo from position B (indirect)
3 reference echo from position C (indirect)
4 reference block
5 reference reflector
6 distance–amplitude curve (DAC)

Figure 13 — Generation of a DAC

5.4.5
transfer correction
correction of the gain setting of the *ultrasonic instrument* (5.1.1) when transferring the *probe* (5.2.1) from a *calibration* (5.4.1) or *reference block* (5.4.2) to the test object

Note 1 to entry: Transfer correction includes losses due to coupling, surface reflection and *attenuation* (4.3.1).

6 Terms related to ultrasonic testing

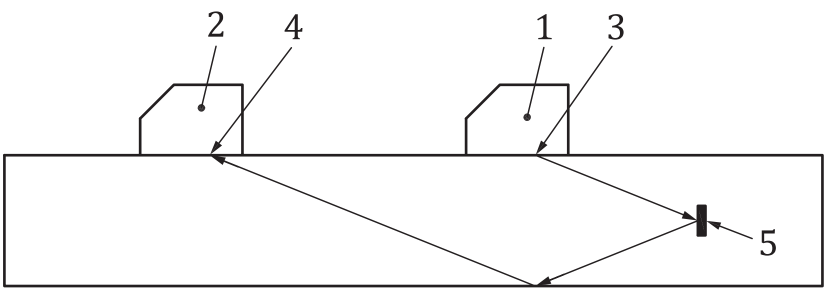
6.1 Testing techniques

6.1.1
pulse–echo technique
technique in which an ultrasonic pulse is transmitted and any *echo* (6.5.1) received by the same *probe* (5.2.1) before the next (successive) *pulse* (3.2.7) is transmitted

6.1.2
tandem technique
scanning technique involving the use of two or more *angle-beam probes* (5.2.13), usually having the same angle, facing in the same direction and having their ultrasonic beam axes in the same plane perpendicular to the *test surface* (6.2.1), where one *probe* (5.2.1) is used for transmission and the other for reception

Note 1 to entry: The purpose of the technique is mainly to detect discontinuities perpendicular to the *test surface* (6.2.1).

Note 2 to entry: See Figure 14.



Key

1 transmitter probe
2 receiver probe
3 point of incidence
4 receiving point
5 reflector

NOTE The function of the transmitter probe and receiver probe can be reversed.

Figure 14 — Tandem technique

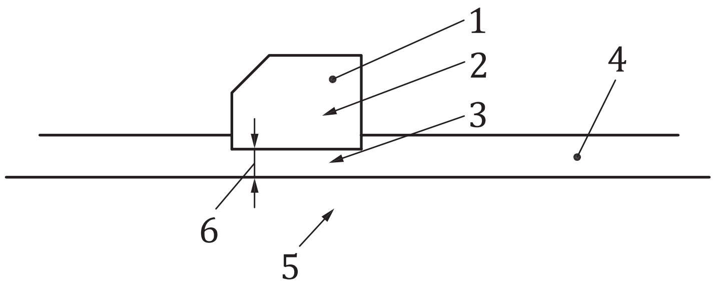
6.1.3
through-transmission technique
technique in which the quality of a material is assessed by transmitting *ultrasonic waves* (3.2.1) through the entire material, using a transmitter probe on one side of the object and a receiver probe on the opposite side

6.1.4
contact technique
technique to test an object by means of an ultrasonic probe (or probes) in direct contact with it usually using a thin layer of *couplant* (6.3.3) between the *probe* (5.2.1) and the object

Note 1 to entry: For techniques without direct contact, see *gap technique* (6.1.5) or *immersion technique* (6.1.6).

6.1.5
gap technique
technique in which the *probe* (5.2.1) is not in direct contact with the surface of the test object, but is coupled to it through a layer of liquid, not more than a few *wavelengths* (3.2.4) thick

Note 1 to entry: See Figure 15.



Key

1 angle-beam probe
2 probe index point
3 couplant path
4 couplant
5 point of incidence
6 gap

Figure 15 — Gap technique

6.1.6
immersion technique
technique in which the test object and the *probe* (5.2.1) are immersed in a liquid used as *coupling medium* (6.3.3)

Note 1 to entry: Immersion can be total or partial. Applications using a water jet are also included.

Note 2 to entry: Depending on the probe setup and object geometry, beam refraction will occur.

6.1.7
multiple-echo technique
technique in which repeated echoes from either the back surface or a discontinuity are used for the evaluation of echo amplitude and/or sound path

Note 1 to entry: In order to evaluate the quality of a material or bonding, the *amplitudes* (3.2.2) of successive echoes are used.

Note 2 to entry: In order to increase the accuracy of a wall thickness (sound path) measurement, a *multiple echo* (6.5.8) of highest possible number is used.

6.1.8
loss of back-wall echo
significant reduction of the *amplitude* (3.2.2) of the *echo* (6.5.1) from the back surface

6.1.9
time-of-flight diffraction technique
TOFD technique
technique using the *time-of-flight* (3.2.6) of diffracted signals from discontinuities in the test object

Note 1 to entry: Usually a pair of *angle-beam probes* (5.2.13) using *longitudinal waves* (3.3.1), one transmitting one receiving, is arranged symmetrically to the area of interest.

Note 2 to entry: For example, see ISO 16828.

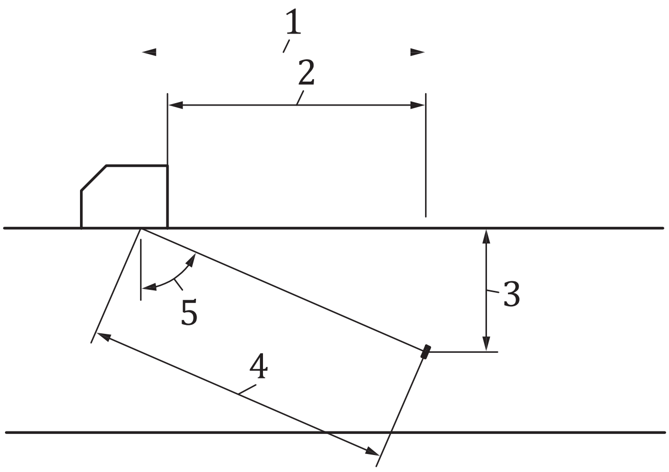
6.1.10
synthetic aperture focusing technique
SAFT
technique to improve the resolution of ultrasonic images by synthetically extending the aperture of a non-focusing probe achieved by digital processing several successive measurements

6.1.11
scanning
displacement of the *probe(s)* (5.2.1) relative to the test object

Note 1 to entry: Scanning can be done manually by the operator or automated using mechanized device(s).

6.1.12
direct scanning technique
scanning (6.1.11) in which a *sound beam* (4.2.2) is directed into a region of a test object without intermediate reflection

Note 1 to entry: See Figure 16.



Key

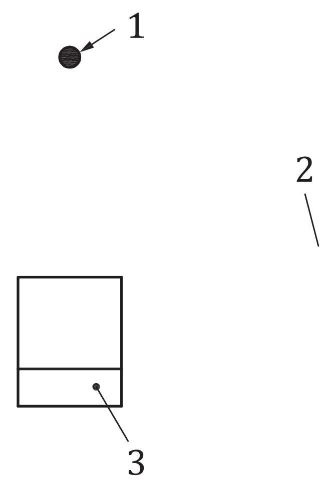
1 projected sound path length
2 reduced projected sound path length
3 reflector depth
4 sound path length
5 angle of refraction

Figure 16 — Direct scanning

6.1.13
indirect scanning technique
scanning (6.1.11) in which a *sound beam* (4.2.2) is directed into a region of a test object by using *reflection(s)* (4.4.3) at surface(s) of the test object

6.1.14
orbital scanning
scanning (6.1.11) in which an *angle-beam probe* (5.2.13) is used to obtain information about the form of a discontinuity previously located, the scanning being made radially around the discontinuity

Note 1 to entry: See Figure 17.



Key

1 centre of circular motion

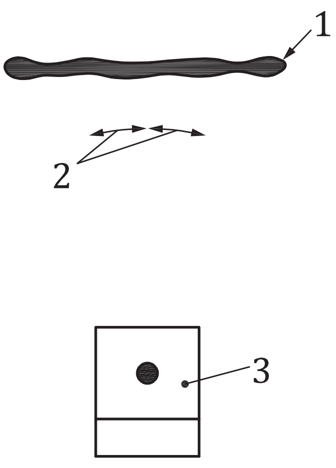
2 orbit

3 angle-beam probe

Figure 17 — Orbital scanning

6.1.15
swivel scanning
scanning (6.1.11) using an *angle-beam probe* (5.2.13) involving rotation of the *probe* (5.2.1) around an axis through the index point perpendicular to the scanning surface

Note 1 to entry: See Figure 18.



Key

1 reflector

2 swivel angle

3 angle-beam probe

Figure 18 — Swivel scanning

6.1.16
spiral scanning
scanning (6.1.11) of a disc-shaped object by means of radial displacement and simultaneous rotation (spiral trace)

6.1.17
helical scanning
scanning (6.1.11) of a cylindrical object by means of longitudinal displacement and simultaneous rotation (helical trace)

6.1.18
automated ultrasonic testing
AUT
technique by which an object is tested by ultrasound using *probes* (5.2.1) operating under mechanical control and where ultrasonic data is collected automatically

Note 1 to entry: The data may also be analyzed automatically against predetermined criteria without human intervention.

6.1.19
acoustical imaging
generation of an image of an object by using ultrasound

6.1.20
acoustical holography
generation of 3D images of a test object by reconstructing information from the *sound field* (4.2.1) reflected from within the test object located in the sound field

6.1.21
acoustical tomography
generation of a 3D image of a test object from 2D acoustic images representing sections through it

6.1.22
measurement modes
techniques by which the ultrasonic echo pulses are used for determination of time differences

6.1.23
flank-to-flank measurement mode
measurement of the time difference between similar edges (flanks) of two *echoes* (6.5.1), usually defined as rising (leading) or falling (trailing) edge, at a specified *amplitude* (3.2.2)

6.1.24
peak-to-peak measurement mode
measurement of the time difference between the maximum amplitudes of two *echoes* (6.5.1)

6.1.25
zero crossing measurement mode
measurement of the time difference between corresponding *zero crossings* (6.1.26) of two *echoes* (6.5.1)

6.1.26
zero crossing
time when the instantaneous amplitude of an unrectified signal reverses polarity

6.2 Test object

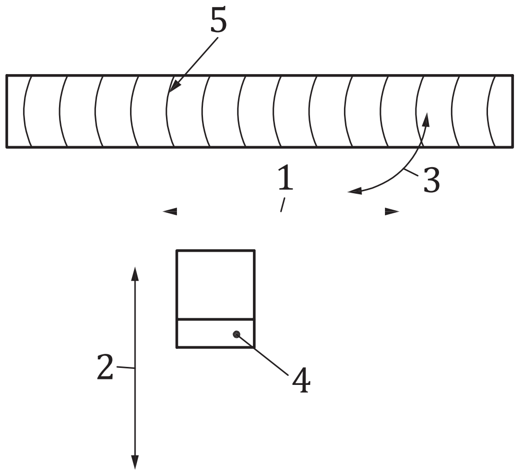
6.2.1
test surface
scanning surface
part of the surface of a test object over which a *probe* or *probes* (5.2.1) is/are moved

6.2.2
test area
defined area on the test object over which the tests are to be conducted

6.2.3
test volume
volume of the test object which is covered by a test

6.2.4
probe orientation
angle maintained during *scanning* (6.1.11) between a reference line and the projection of the *beam axis* (4.2.3) onto the *test surface* (6.2.1)

Note 1 to entry: See Figure 19.



Key

1 scanning direction parallel to the weld
2 scanning direction perpendicular to the weld
3 probe orientation
4 angle-beam probe
5 weld

Figure 19 — Weld testing

6.2.5
scanning direction
direction of movement of a *probe* (5.2.1) over the *test surface* (6.2.1)

Note 1 to entry: See Figure 19.

6.2.6
point of incidence
point on the test object where the *sound beam* (4.2.2) enters the object

Note 1 to entry: See Figures 14 and 15.

6.2.7
receiving point
point on the test object where the reflected or transmitted *sound beam* (4.2.2) can be received

Note 1 to entry: See Figure 14.

6.3 Coupling

6.3.1
acoustical impedance matching
adaptation of *acoustical impedances* (4.4.7) of two coupled pieces of material, so as to provide optimum transfer of ultrasound between them

6.3.2
coupling techniques
techniques by which ultrasound is transmitted (coupled) from the *probe* (5.2.1) into the test object and vice versa

6.3.3
couplant
coupling medium
medium interposed between the *probe* (5.2.1) and the test object to enable the passage of ultrasound between them, such as water, glycerine or oil

Note 1 to entry: See Figure 15.

6.3.4
couplant path
distance in the *coupling medium* (6.3.3) between the *probe index point* (5.2.16) and the *point of incidence* (6.2.6)

Note 1 to entry: See Figure 15.

6.3.5
coupling losses
reduction of sound transmission across the *interface* (4.4.1) between a *probe* (5.2.1) and a test object

6.4 Reflectors

6.4.1
reflector
interface (4.4.1) at which an ultrasonic beam encounters a change in acoustic impedance and at which at least part of the ultrasound is reflected

Note 1 to entry: See Figures 14 and 18.

6.4.2
reference reflector
reflector (6.4.1) (natural or artificial) with known form, size and distance from the *test surface* (6.2.1) in the *calibration block* (5.4.1) or *reference block* (5.4.2), which is used for calibration or assessment of *detection sensitivity* (5.3.4)

EXAMPLE *Side-drilled holes* (6.4.4), *flat-bottomed holes* (6.4.3), *hemispherical-bottomed holes* (6.4.5), *notches* (6.4.6).

Note 1 to entry: See Figure 13.

6.4.3
flat-bottomed hole
FBH
disc-shaped reflector
borehole where the flat bottom acts as a disc-shaped reflector perpendicular to the *beam axis* (4.2.3)

6.4.4
side-drilled hole
SDH
cylindrical reflector
borehole perpendicular to the *beam axis* (4.2.3) where the cylindrical surface acts as a *reflector* (6.4.1)

6.4.5
hemispherical-bottomed hole
spherical-shaped reflector
borehole near parallel to the *beam axis* (4.2.3) where the hemispherical bottom acts as a *reflector* (6.4.1)

6.4.6
notch
plane surface-breaking reflector usually perpendicular to the surface where the sides and/or the bottom can act as *reflectors* (6.4.1)

6.5 Signals and indications

6.5.1
echo
signal on the display of the *ultrasonic instrument* (5.1.1) received from the test object

Note 1 to entry: See Figure 20.

Note 2 to entry: Depending on the test setup, additional echoes may be received.

6.5.2
back-wall echo
echo (6.5.1) from the surface of the test object opposite to the *probe* (5.2.1) which is perpendicular to the ultrasonic beam axis

Note 1 to entry: See Figure 20.

6.5.3
surface echo
echo (6.5.1) from the *test surface* (6.2.1), usually present in *immersion technique* (6.1.6) or with *contact technique* (6.1.4) using a *delay block* (5.2.7)

Note 1 to entry: See also *interface echo* (6.5.9).

6.5.4
side wall echo
echo (6.5.1) from a surface of the test object other than the back and *test surface* (6.2.1)

6.5.5
echo width
duration of an *echo* (6.5.1) measured at a specified level

6.5.6
echo height
height of an echo indication on the display

6.5.7
spurious echo
echo (6.5.1) which is not associated with a discontinuity and is of no interest

6.5.8
multiple echo
echo (6.5.1) from repeated reflection of an ultrasonic pulse between two or more *interfaces* (4.4.1) or discontinuities

6.5.9
interface echo
echo (6.5.1) from the *interface* (4.4.1) between dissimilar materials

Note 1 to entry: Usually used for bond testing.

6.5.10
ghost echo
phantom echo
echo (6.5.1) originating from a transmitted pulse generated in a previous cycle

6.5.11
echo pattern
typical pattern of one or more *echoes* (6.5.1) displayed on the instrument

Note 1 to entry: For example, see ISO 23279.

6.5.12
dynamic echo pattern
envelope pattern generated by individual *echoes* (6.5.1) displayed on the instrument when moving the *probe* (5.2.1)

Note 1 to entry: For example, see ISO 23279.

6.5.13
static echo pattern
pattern of individual *echoes* (6.5.1) displayed on the instrument when the *probe* (5.2.1) is not moved

Note 1 to entry: For example, see ISO 23279.

6.5.14
indication
any signal shown on the display of an *ultrasonic instrument* (5.1.1), which can be separated from *noise* (6.5.15), surface and *back-wall echoes* (6.5.2)

6.5.15
noise
undesired signals (electrical or acoustical) that tend to interfere with the reception, interpretation or processing of the desired signal

6.5.16
noise level
amplitudes (3.2.2) of background *noise* (6.5.15) in an ultrasonic system

6.5.17
signal-to-noise ratio
ratio of the amplitude of an ultrasonic signal to the *amplitude* (3.2.2) of the *noise* (6.5.15) at approximately the same location

6.5.18
transmitter pulse indication
indication (6.5.14) of the *transmitter pulse* (5.1.3) on the display of the *ultrasonic instrument* (5.1.1)

Note 1 to entry: See Figure 20.

6.5.19
transmission point
zero point
point on the *time base* (5.1.15) which corresponds to the instant at which ultrasound enters the test object

Note 1 to entry: The transmission point does not necessarily coincide with the *transmitter pulse indication* (6.5.18), e.g. in case of immersion testing or when using a *delay line* (5.2.7).

6.5.20
expanded time base
scale expansion
zooming into a selected section of the set range which enables *echoes* (6.5.1) within the thickness or length of the test object to be displayed in greater detail on the display

6.5.21
display response
time it takes the display device to change from one display state to another

Note 1 to entry: The display response is limiting the scanning speed.

6.5.22
radio frequency signal
RF signal
unrectified signal

Note 1 to entry: In ultrasonic testing, the term radio frequency is misleading, because no radio frequencies are used.

6.6 Presentations

For an overview of the different presentations, see Table 1.

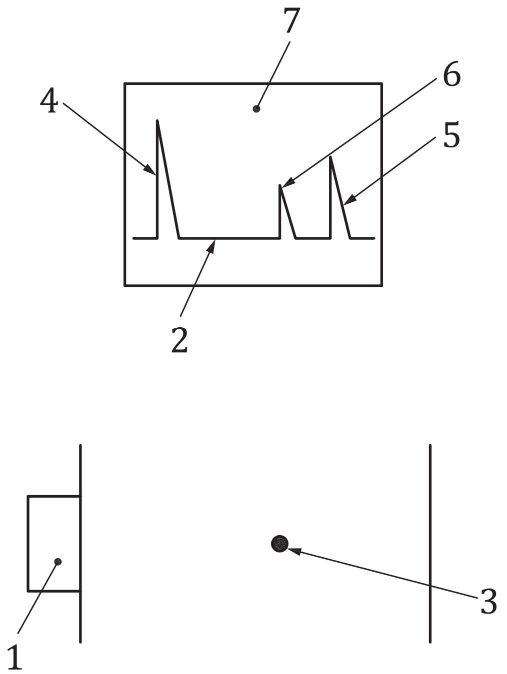
Table 1 — Overview of the different presentations

Type of presentation	Spatial coordinates		Signal amplitude	Time	Other features	Type of data acquisition
	Direction 1 (d_1)	Direction 2 (d_2)	A	t	F	
A-scan (6.6.1)			•	•		$A = f(t)$
B-scan (d_1) (6.6.2)	•		•	•		$A = f(d_1,t)$
B-scan (d_2)[a] (6.6.2)		•	•	•		$A = f(d_2,t)$
C-scan (6.6.3)	•	•	•			$A = f(d_1,d_2)$
F-scan (6.6.4)	•	•			•	$F = f(d_1,d_2)$
T-scan (6.6.6)	•	•		•		$t = f(d_1,d_2)$
V-scan (6.6.7)	•	•	•	•		$A = f(d_1,d_2,t)$

[a] B-scan (d_2) which is perpendicular to B-scan (d_1) is also called D-scan.

6.6.1
A-scan presentation
display of the ultrasonic signals in which the X-axis represents time and the Y-axis represents *amplitude* (3.2.2)

Note 1 to entry: See Figure 20.



Key

1 straight-beam probe
2 time base
3 reflector
4 transmitter pulse indication
5 back-wall echo
6 reflector echo
7 A-scan presentation

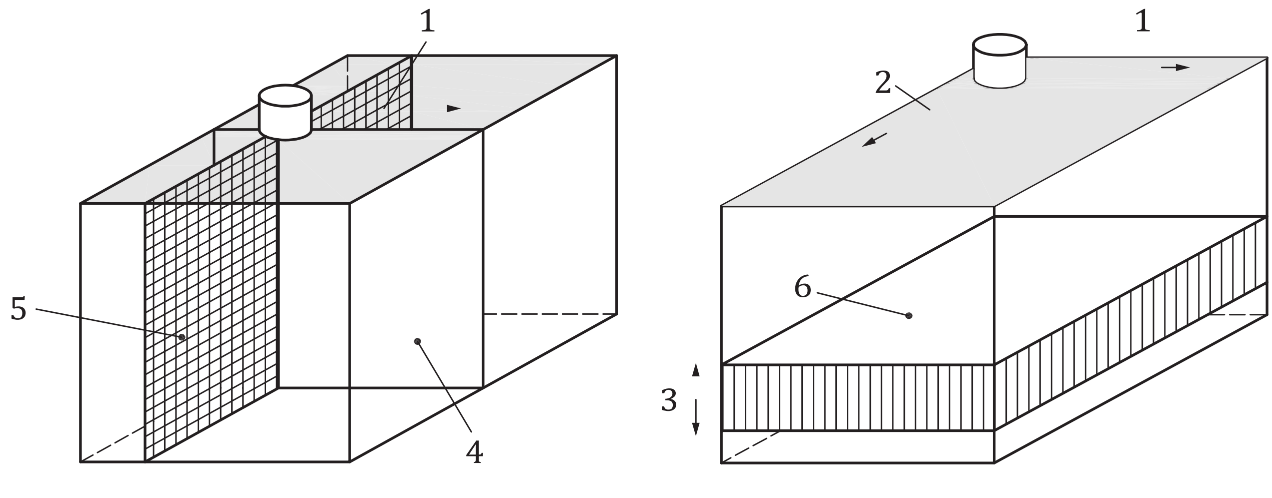
Figure 20 — A-scan presentation

6.6.2
B-scan presentation
display of the ultrasonic signals in which one axis represents time and the other axis represents positions along the scanning surface, where the *amplitude* (3.2.2) of the signals is represented by colour or grey shades

Note 1 to entry: The B-scan represents a collection of A-scans.

Note 2 to entry: Typical B-scans are generated in the *scanning direction* (6.2.5), but they can also be generated perpendicular to the scanning direction (index). This perpendicular scan presentation was also called D-scan.

Note 3 to entry: See Figure 21 a).



Key

1 direction 1 (d_1)

2 direction 2 (d_2)

3 depth-zone within gate

4 B-scan presentation of d_1

5 B-scan presentation of d_2

6 C-scan presentation, T-scan presentation, F-scan presentation

Figure 21 — Area imaged in different presentations

6.6.3
C-scan presentation
display of the ultrasonic signals in which both axes represent positions on the scanning surface, where the *amplitude* (3.2.2) of the signals within a defined time window is represented by colour or grey shades

Note 1 to entry: See Figure 21 b).

6.6.4
F-scan presentation
display of the ultrasonic signals in which both axes represent positions on the scanning surface, where an optional parameter of the signals, different from *amplitude* (3.2.2) and *time-of-flight* (3.2.6), within a defined time window is represented by colour or grey shades

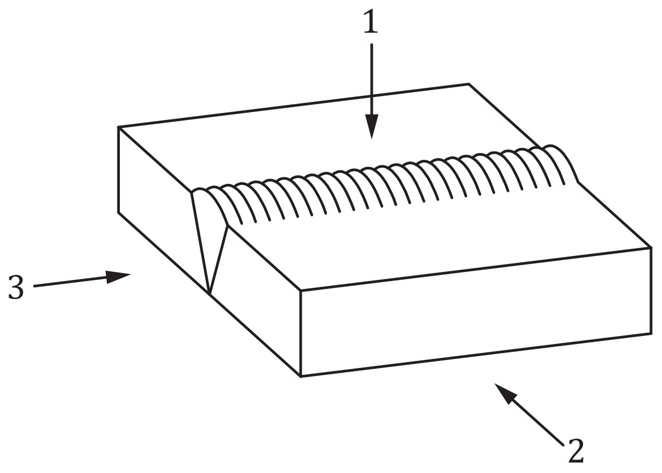
Note 1 to entry: See Figure 21 b).

Note 2 to entry: For example, *sound velocity* (4.2.19) and *centre frequency* (3.1.5).

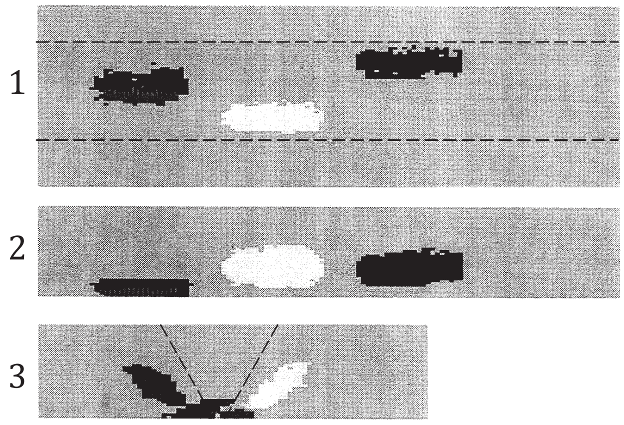
6.6.5
P-scan presentation
projection of scan presentations related to orthogonal directions typically called top view, side view and end view

Note 1 to entry: The evaluated parameter in the images is the *amplitude* (3.2.2) of the signal.

Note 2 to entry: See Figure 22.



a) Test object with weld



b) P-scan presentations

Key

1 top view

2 side view

3 end view

Figure 22 — P-scan presentations

6.6.6
T-scan presentation

display of the ultrasonic signals in which both axes represent positions on the scanning surface, where the *time-of-flight* (3.2.6) of the signals within a defined time window is represented by colour or grey shades

Note 1 to entry: In the past, this type of presentation was also called time-of-flight C-scan or thickness C-scan.

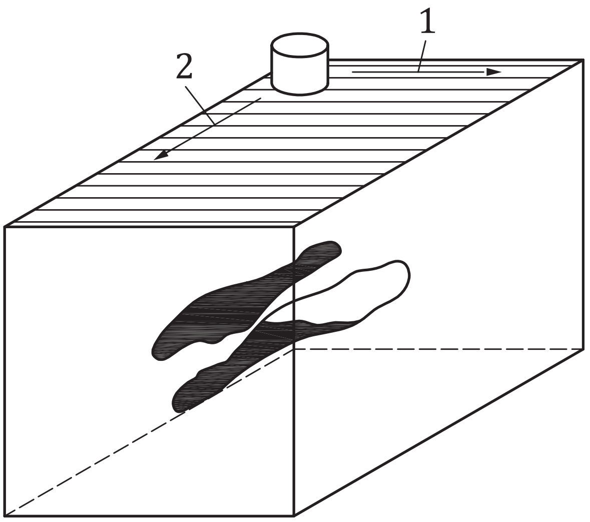
Note 2 to entry: See Figure 21 b).

6.6.7
V-scan presentation

volume scan presentation

three-dimensional (spatial) representation of the results of the tested volume

Note 1 to entry: See Figure 23.



Key

1 direction 1

2 direction 2

Figure 23 — V-scan presentation

6.7 Location

6.7.1
sound path length
length of the path ultrasonic pulses travel within a test object (single trip)

Note 1 to entry: See Figure 16.

6.7.2
projected sound path length
projection of the *sound path length* (6.7.1) on the *test surface* (6.2.1)

Note 1 to entry: See Figure 16.

6.7.3
reduced projected sound path length
projection of the *sound path length* (6.7.1) on the *test surface* (6.2.1) reduced by the distance between the *probe index point* (5.2.16) and the front of the *probe* (5.2.1)

Note 1 to entry: See Figure 16.

6.7.4
sound path travel distance
total (round trip) distance ultrasonic pulses travel

6.7.5
sound path travel time
time it takes for ultrasonic pulses to travel along the *sound path travel distance* (6.7.4)

6.7.6
skip distance
full skip
distance on the *test surface* (6.2.1) between the *point of incidence* (6.2.6) of an angled beam and the point at which the *beam axis* (4.2.3) impinges on the test surface after a single *reflection* (4.4.3) at the opposite surface

6.7.7
reflector depth
shortest distance from a *reflector* (6.4.1) to the test surface

Note 1 to entry: See Figure 16.

6.8 Evaluation of indications

6.8.1
characterization of an indication
determines the position, size and shape of an *indication* (6.5.14)

6.8.2
classification of an indication
decides into which class an *indication* (6.5.14) belongs

6.8.3
combined length of indications
accumulated length where *indications* (6.5.14) are grouped

6.8.4
discontinuity sizing
estimation of the size of a discontinuity from its ultrasonic indications

6.8.5
reflectivity
ratio of the echo amplitude from the *reflector* (6.4.1) under assessment to the echo amplitude from a *reference reflector* (6.4.2)

6.8.6
directional reflectivity
variation in the echo amplitude from a *reflector* (6.4.1) with change of incident angle

6.8.7
reference level
level defined by the echo amplitude of a defined *reference reflector* (6.4.2)

6.8.8
reporting level
level above (or below) which every *echo* (6.5.1) has to be reported

6.8.9
registration level
recording level
level above (or below) which every *echo* (6.5.1) has to be registered or recorded

6.8.10
evaluation level
level above or below which *indications* (6.5.14) have to be evaluated or examined further

6.8.11
display level
optional minimum amplitude of *indications* (6.5.14) which are displayed graphically in section or projection views

6.8.12
acceptance level
level defining limits for acceptance regarding *echo height* (6.5.6), position, classification (if applicable) and number of *indications* (6.5.14) or size of discontinuities

6.8.13
testing sensitivity
sensitivity setting which has to be used during the test

6.8.14
distance–gain-size diagram
DGS diagram
series of curves which show the relationship between distance along the *beam axis* (4.2.3) and *gain* (5.1.7) in decibels for an infinite reflector and for different sizes of *disc-shaped reflectors* (6.4.3)

6.8.15
distance–amplitude curve
DAC
reference curve constructed between the peak amplitude responses from identical reflectors located at different distances from the *probe* (5.2.1) in the same material

Note 1 to entry: See Figure 13.

Note 2 to entry: This term shall not be confused with *distance–amplitude compensation* (5.1.12).

6.8.16
time-corrected gain
TCG
method of compensation for the reduction of signal amplitudes with increasing sound path, so that all reference echo amplitudes after compensation reach a constant level

Note 1 to entry: This definition of *time-corrected gain* differs from the definition of the same term given by 5.1.12.

6.8.17
half-amplitude technique
6-dB-drop technique
technique of reflector size assessment (length, height and/or width) wherein the *probe* (5.2.1) is moved from a position showing maximum echo amplitude until the *echo* (6.5.1) has decreased to half of this value (by 6 dB)

Note 1 to entry: This technique can only be used for *reflectors* (6.4.1) larger than the *beam width* (4.2.6) in the direction of *scanning* (6.1.11).

6.8.18
20-dB-drop technique
technique of reflector size assessment (length, height and/or width) wherein the *probe* (5.2.1) is moved from a position showing maximum echo amplitude until the *echo* (6.5.1) has decreased to one-tenth of this value (by 20 dB)

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[4] ISO 16946, *Non-destructive testing — Ultrasonic testing — Specification for step wedge calibration block*

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[6] EN 16018, *Non-destructive testing — Terminology — Terms used in ultrasonic testing with phased arrays*

ICS 19.100; 01.040.19
Price code A