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C H A P T E R

## **Ultrasonic Testing Glossary**

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# PART 1. Terms

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## Introduction

Many of the definitions in this glossary are adapted from the second and third edition of the *Nondestructive Testing Handbook*.<sup>1-16</sup> The definitions have been modified to satisfy peer review and editorial style. For this reason, references at the end of this glossary should be considered not attributions but acknowledgments and suggestions for further reading.

The definitions in this *Nondestructive Testing Handbook* volume should not be referenced for tests performed according to standards, specifications or contracts. Written procedures should refer to definitions in standards.

This glossary is provided for instructional purposes. No other use is intended.

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## A

**acceptance standard:** Document defining acceptable discontinuity size limits.<sup>7</sup> See also *standard*.

**acoustic emission:** Transient elastic waves resulting from local internal microdisplacements in a material. By extension, the term also describes the technical discipline and measurement technique relating to this phenomenon.<sup>16</sup>

**acoustic impedance:** Material property defined as the product of sound velocity and density of the material. The relative transmission and reflection at an interface are governed in part by the acoustic impedances of the materials on each side of the interface.<sup>7,22</sup> See also *characteristic acoustic impedance*; *specific acoustic impedance*.

**acoustic microscopy:** General term referring to the use of high resolution, high frequency ultrasonic techniques to produce images of features beneath the surface of a test object.<sup>7</sup>

**AE:** *Acoustic emission* method of nondestructive testing.

**amplitude linearity:** See *linearity*, *amplitude*.

**amplitude, echo:** Vertical height of a received signal on an A-scan, measured from base to peak for a video presentation or from peak to peak for a radio frequency presentation.<sup>7</sup>

**analog-to-digital converter:** Circuit whose input is analog and whose output is digital.<sup>16</sup>

**angle beam:** Ultrasound beam traveling at an acute angle into a medium. The angle of incidence or angle of refraction is measured from the normal to the entry surface.<sup>7,22</sup>

**angle of incidence:** Included angle between the beam axis of the incident wave and the normal to the surface at the point of incidence.<sup>7,21</sup>

**angle of reflection:** Included angle between the beam axis of the reflected wave and the normal to the reflecting surface at the point of reflection.<sup>7,21</sup>

**angle of refraction:** Angle between the beam axis of a refracted wave and the normal to the refracting interface.<sup>7,21</sup>

**angle beam testing:** Technique of ultrasonic testing in which transmission of ultrasound is at an acute angle to the entry surface.<sup>7,21</sup>

**angle beam transducer:** Transducer that transmits or receives ultrasonic energy at an acute angle to the surface. This may be done to achieve special effects such as setting up transverse or surface waves by mode conversion at an interface.<sup>7,21</sup>

**anisotropy:** Condition in which properties of a medium (velocity, for example) depend on direction in the medium.

**anomaly:** Variation from normal material or product quality.<sup>10</sup>

**antinode:** Point in a standing wave where certain characteristics of the wave field have maximum amplitude.<sup>7,21</sup>

**area linearity:** See *linearity*, *area*.

**array:** Group of transducers used for source location.<sup>16</sup>

**array transducer:** Transducer made up of several piezoelectric elements individually connected so that the signals they transmit or receive may be treated separately or combined as desired.<sup>7</sup> See also *phased array*.

**artificial discontinuity standard:** See *acceptance standard*.

**A-scan:** One-dimensional display of ultrasonic signal amplitude as function of time or depth in test object.

**ASNT Recommended Practice**  
*No. SNT-TC-1A: See Recommended Practice No. SNT-TC-1A.*

**ASNT:** American Society for Nondestructive Testing.

**attenuation coefficient:** Factor determined by the degree of diminution in sound wave energy per unit distance traveled. It is composed of two parts, one (absorption) proportional to frequency, the other (scattering) dependent on the ratio of grain size or particle size to wavelength.<sup>7,23</sup> See also *ultrasonic absorption*.

**attenuation:** (1) Decrease in acoustic energy over distance. This loss may be caused by absorption, leakage, reflection, scattering or other material characteristics. (2) Decrease in signal amplitude caused by acoustic energy loss or by an electronic device such as an attenuator.<sup>10,16,21</sup>

**attenuator:** Device for varying the signal amplitude on an ultrasonic instrument. Usually calibrated in decibels.<sup>7,21</sup>

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## B

**back reflection:** Signal received from the far boundary or back surface of a test object.<sup>7,21</sup>

**background noise:** Extraneous signals caused by random signal sources within or exterior to the ultrasonic testing system, including the test material.<sup>7,21</sup> It has electrical, mechanical or chemical origins.<sup>16</sup> Sometimes called *grass* or *hash*.

**baseline:** Horizontal trace across the A-scan display. It represents time and is generally related to material distance or thickness.<sup>7</sup>

**beam exit point:** See *probe index*.

**beam spread:** Widening of the sound beam as it travels through a medium.<sup>21</sup> Specifically, the solid angle that contains the main lobe of the beam in the far field.<sup>7</sup>

**bel (B):** See *decibel*.

**boundary echo:** Reflection of an ultrasonic wave from an interface.<sup>7,22</sup>

**brittleness:** Material characteristic that leads to crack propagation without appreciable plastic deformation.<sup>10</sup>

**broad band:** Having a relatively wide frequency bandwidth. Used to describe pulses that display a wide frequency spectrum and receivers capable of amplifying them.<sup>7</sup>

**B-scan:** Data presentation technique typically applied to pulse echo techniques. It produces a two-dimensional view of a cross sectional plane through the test object. The horizontal sweep is proportional to the distance along the test object and the vertical sweep is proportional to depth, showing the front and back surfaces and discontinuities between.<sup>7,22</sup>

**bubbler:** See *water column*.

**burst, forging:** See *crack, forging*.

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## C

**calibration, basic:** Procedure of standardizing an instrument by using a reference standard.

**calibration reflector:** Reflector with a known dimensioned surface in a specified material, established to provide an accurately reproducible reference level.<sup>7</sup> See also *reference standard*.

**cathode ray:** Stream of electrons emitted by a heated filament and projected in a more or less confined beam under the influence of a magnetic or electric field.<sup>7,22</sup>

**cathode ray tube:** Vacuum tube containing a screen on which ultrasonic scans may be displayed. Used for A-scans or B-scans in the twentieth century.<sup>7</sup>

**certification:** With respect to nondestructive test personnel, the process of providing written testimony that an individual has met the requirements of a specific practice or standard. See also *certified* and *qualified*.

**certified:** With respect to nondestructive test personnel, having written testimony of qualification. See also *certification* and *qualification*.

**characteristic acoustic impedance:** Acoustic impedance typical or characteristic of a particular material. See *acoustic impedance; specific acoustic impedance*.

**compensator:** Electrical matching network to compensate for electrical impedance differences.<sup>7,22</sup>

**compressional wave:** Wave in which particle motion in the material is parallel to the wave propagation direction. Also called *longitudinal wave*.<sup>7</sup>

**contact technique:** Testing technique in which the transducer face makes direct contact with the test object through a thin film of couplant.<sup>7,22</sup>

**contact transducer:** Transducer used in the contact technique.<sup>7</sup>

**continuous wave:** Wave of constant amplitude and frequency.

**contracted sweep:** Misnomer that refers to extending the duration of the sweep to permit viewing discontinuities or back reflections from deeper in the test object. The sweep appears to be compressed.<sup>7</sup>

**corner effect:** Strong reflection obtained when an ultrasonic beam is directed toward the intersection of two or three intersecting surfaces.<sup>7,22</sup>

**couplant:** Substance used between the transducer and the contacting surface to permit or improve transmission of ultrasonic energy into or from the test object.<sup>7,22</sup>

**crack:** (1) Break, fissure or rupture, sometimes V shaped in cross section and relatively narrow. By convention, a discontinuity is called a *crack* if it is at least three times longer than it is wide. (2) Propagating discontinuity caused by fatigue, corrosion or stresses such as heat treating or grinding. May be difficult to detect unaided because of fineness of line and pattern (may have a radial or latticed appearance).<sup>10</sup>

**crack, cold:** Crack that occurs after solidification, because of high stresses from nonuniform cooling.<sup>10</sup>

**crack, cooling:** Crack resulting from uneven cooling after heating or hot rolling. Cooling cracks are usually deep and lie in a longitudinal direction but are usually not straight.<sup>10</sup>

**crack, fatigue:** Progressive growth of a crack that usually develops on the surface and is caused by the repeated loading and unloading of the object.<sup>10</sup>

**crack, forging:** Crack developed by forging at too low a temperature, resulting in rupturing of the material.<sup>10</sup> Also called *burst*.

**crack, hot:** Crack that develops before the material has completely cooled, as contrasted with cold cracks that develop after solidification.<sup>10</sup>

**crack, quenching:** During quenching of hot metal, rupture produced by more rapid cooling and contraction of one portion of a test object than occur in adjacent portions.<sup>10</sup>

**critical angle:** Incident angle of the ultrasound beam where the refracted beam is parallel to the surface and above which a specific mode of refracted energy no longer exists.<sup>7,21</sup>

**cross coupling:** *Cross talk*.

**cross noise:** *Cross talk*.

**cross talk:** Unwanted signal leakage (acoustical or electrical) across an intended barrier, such as leakage between the transmitting and receiving elements of a dual transducer.<sup>7,22</sup> Also called *cross noise* and *cross coupling*.

**CRT:** See *cathode ray tube*.

**crystal:** See *transducer element*.

**crystal, X-cut:** Cut with face perpendicular to the X-direction of the piezoelectric crystal.<sup>7</sup> In a quartz slice so cut, a thickness mode of vibration occurs when the slice is electrically stimulated in the X direction.<sup>7,22</sup>

**crystal, Y-cut:** Piezoelectric crystal whose cut face is perpendicular to the Y direction. In quartz, a transverse mode of vibration is obtained when the slice is electrically stimulated in the Y direction.<sup>7,22</sup>

**crystal mosaic:** Multiple crystals mounted in the same surface on one holder and connected so as to cause all to vibrate as one unit.<sup>7,22</sup>

**C-scan:** Presentation technique applied to acoustic data and displaying an image of two-dimensional test object with scaled grays or colors representing the ultrasonic signals. The amplitude represented in each pixel may be a pulse echo, through-transmission or pitch catch value calculated from each A-scan datum.

**cutoff frequency:** Upper or lower spectral response of a filter or amplifier, at which the response is a specified amount less (usually 3 or 6 dB) than the maximum response.

## D

**damping:** (1) Limiting the duration or decreasing the amplitude of vibrations, as when damping a transducer element.<sup>22</sup> (2) Deliberate introduction of energy absorbers to reduce vibrations.<sup>7</sup>

**damping capacity:** Measure of the ability of a material to dissipate mechanical energy.<sup>7,23</sup>

**damping material:** Highly absorbent material used to cause rapid decay of vibration.<sup>7</sup>

**damping, transducer:** Material bonded to the back of the piezoelectric element of a transducer to limit the duration of vibrations.<sup>7,21</sup>

**damping, ultrasonic:** Decrease or decay of ultrasonic wave amplitude controlled by the instrument or transducer.

**dead zone:** Interval following the initial pulse at the surface of a test object to the nearest inspectable depth.<sup>21</sup> Any interval following a reflected signal where additional signals cannot be detected.<sup>7</sup>

- decibel (dB):** Logarithmic unit for expressing relative signal power, such as the loudness of a sound, in proportion to the intensity of a reference signal. One tenth of a *bel*. Decibel in signal amplitude is twice that in signal power.<sup>16</sup> One decibel equals ten times the base ten logarithm of the ratio of two powers.
- defect:** Discontinuity whose size, shape, orientation or location (1) makes it detrimental to the useful service of its host object or (2) exceeds an accept/reject criterion of an applicable specification.<sup>10,18</sup> Some discontinuities do not exceed an accept/reject criterion and are therefore not defects. Compare *crack*; *discontinuity*; *indication*.<sup>10</sup>
- delamination:** Lamellar discontinuity, generally an area of unbonded materials.<sup>7</sup>
- delay line:** Material (liquid or solid) placed in front of a transducer to cause a time delay between the initial pulse and the front surface reflection.<sup>7,22</sup>
- delayed sweep:** See *sweep delay*.
- delayed time base:** See *delayed sweep*.
- delta effect:** Reradiation or diffraction of energy from a discontinuity.<sup>22</sup> The reradiated energy may include waves of both the incident mode and converted modes (longitudinal and transverse).<sup>7</sup>
- delta t ( $\Delta t$ ):** Duration measured between two points in time. Also called *time differential*.
- depth compensation:** See *distance amplitude correction*.
- depth of field:** *Focal zone*.
- depth of focus:** *Focal zone*.
- detectability:** A measure of the ability to detect signals from small reflectors. Limited by the signal-to-noise ratio.
- diffraction:** Deflection of a wavefront when passing the edge of an ultrasonically opaque object.<sup>7,22</sup>
- diffuse reflection:** Scattered, incoherent reflections from rough surfaces.<sup>7,21</sup>
- discontinuity:** Interruption in the physical structure or configuration of a test object. After nondestructive testing, a discontinuity indication can be interpreted to be a *flaw* or a *defect*.<sup>10</sup> Compare *defect*; *indication*.
- dispersion:** In acoustics, variation of wave phase with frequency.<sup>7</sup>
- dispersive medium:** Medium in which the propagation velocity depends on the wave frequency.<sup>7</sup>
- distance amplitude correction:** Compensation of gain as a function of time for difference in amplitude of reflections from equal reflectors at different sound travel distances.<sup>7</sup> Refers also to compensation by electronic means such as swept gain, time corrected gain, time variable gain and sensitivity time control.<sup>7,22</sup>
- divergence:** Term sometimes used to describe the spreading of ultrasonic waves beyond the near field. It is a function of transducer diameter and wavelength in the medium.<sup>7</sup> See *beam spread*.
- double-crystal technique:** See *pitch catch technique*.
- dual transducer:** See *send/receive transducer*.
- dynamic range:** Ratio of maximum to minimum reflective areas that can be distinguished on the display at a constant gain setting.<sup>7,19</sup>

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## E

- echo:** Reflected acoustic energy or signal indicating such energy.<sup>7</sup>
- effective penetration:** In a material, the maximum depth at which a test signal can reveal discontinuities.
- electrical noise:** Extraneous signals caused by external sources or electrical interferences within an ultrasonic instrument.<sup>21</sup> A component of *background noise*.<sup>7</sup>
- electromagnetic acoustic transducer:** Transmitting transducer based on the force exerted on a current flowing in a magnetic field. A receiving transducer that detects the current produced by moving a conductor in a magnetic field.<sup>7</sup>
- EMAT:** See *electromagnetic acoustic transducer*.
- evaluation:** Process of deciding the severity of a condition after an indication has been interpreted. Evaluation determines if the test object should be rejected or accepted.<sup>7</sup> See also *indication* and *interpretation*.
- expanded sweep:** Short duration horizontal sweep positioned to allow close examination of a signal.<sup>7</sup>

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## F

**false indication:** See *indication, false*.

**far field:** Zone beyond the near field in front of a plane transducer in which signal amplitude decreases monotonically in proportion to distance from the transducer.<sup>7</sup> Also called the *fraunhofer zone*.

**filter:** (1) Electrical circuit that leaves a signal unaffected over a prescribed range of frequencies and attenuates signal components at all other frequencies.<sup>10,20</sup> (2) Data analysis process for treating data files.

**flat bottom hole:** Type of reflector commonly used in reference standards. The end (bottom) surface of the hole is the reflector.<sup>7</sup>

**flaw location scale:** Specially graduated ruler that can be attached to an angle beam transducer to relate the position of an indication on the display to the actual location of a discontinuity within the test object.<sup>7</sup>

**flaw:** Unintentional anomaly or imperfection. See also *defect* and *discontinuity*.<sup>10</sup>

**focal zone:** Distance before and after the focal point in which the intensity differs a specified amount (usually 6 dB) from the focal intensity.<sup>7</sup> Also called *depth of field* or *depth of focus*.

**focused beam:** Sound beam that converges to a cross section smaller than that of the element.

**focused transducer:** Transducer that produces a focused sound beam.<sup>7</sup>

**fraunhofer zone:** See *far field*.

**frequency, fundamental:** In resonance testing, the frequency at which the wavelength is twice the thickness of the test material.<sup>7,22</sup>

**frequency, pulse repetition:** Number of pulses per second.<sup>7</sup>

**frequency, test:** Nominal ultrasonic wave frequency used.<sup>7,22</sup>

**frequency:** Number of complete wave cycles passing a given point per second or the number of vibrations per second.<sup>7</sup>

**fresnel field:** See *near field*.

**fresnel zone:** See *near field*.

**front surface:** First surface of the test object encountered by an ultrasonic beam.<sup>7</sup>

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## G

**gate:** (1) Electronic device for selecting signals in a segment of the trace on an A-scan display. (2) The interval along the baseline that is monitored.<sup>7</sup>

**general examination:** In personnel qualification, a test or examination of a person's knowledge, typically (in the case of nondestructive test personnel qualification) a written test on the basic principles of a nondestructive test method and general knowledge of basic equipment used in that method. (According to ASNT's guidelines, the general examination should not address knowledge of specific equipment, codes, standards and procedures pertaining to a particular application.)<sup>10</sup>

**ghost:** Aliasing indication arising from certain combinations of pulse repetition frequency and time base frequency.<sup>7,23</sup> See also *wrap around*.

**grass:** See *background noise*.

**grinding crack:** Shallow crack formed in the surface of relatively hard materials because of grinding heat. Grinding cracks typically are 90 degrees to the direction of grinding.<sup>10</sup>

**group velocity:** Speed at which the envelope of an ultrasonic pulse (many frequencies) propagates through the medium.<sup>7</sup>

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## H

**hardness:** Resistance of metal to denting, to plastic deformation by bending or to mechanical deformation by scratching, abrasion or cutting. Typically measured by indentation.

**harmonic:** Vibration frequency that is an integral multiple of the fundamental frequency.<sup>7,21</sup>

**hash:** See *background noise*.

**heat affected zone:** Base metal that was not melted during brazing, cutting or welding but whose microstructure and physical properties were altered by the heat.<sup>10</sup>

**hertz (Hz):** Measurement unit of frequency, equivalent to one cycle per second.<sup>10,17</sup>

**horizontal linearity:** Measure of proportionality between positions of indications on the horizontal trace and the positions of their corresponding reflectors.

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## I

**immersion technique:** Test technique in which the test object and the transducer are submerged in a liquid (usually water) that acts as the coupling medium.<sup>22</sup> The transducer is not usually in contact with the test object.<sup>7</sup>

**impedance, acoustic:** See *acoustic impedance*.

**indication:** Nondestructive test equipment response to a reflector, requiring interpretation to determine its relevance. Compare *crack*; *defect*; *discontinuity*; *indication, false*.<sup>10</sup>

**indication, discontinuity:** Visible evidence of a material discontinuity. Subsequent interpretation is required to determine the indication's significance.<sup>10</sup>

**indication, false:** Test indication that originates where no discontinuity exists in the test object. Compare *defect*; *indication, nonrelevant*.<sup>10</sup>

**indication, nonrelevant:** Indication possibly caused by an actual discontinuity that does not affect the usability of the test object (a change of section, for instance) or that is smaller than a relevant indication. Compare *indication, false* and *indication, relevant*.<sup>10</sup>

**indication, relevant:** Indication from a discontinuity (as opposed to a nonrelevant indication) requiring evaluation by a qualified inspector, typically with reference to an acceptance standard, by virtue of the discontinuity's size, shape, orientation or location. Compare *indication, nonrelevant*.<sup>10,19</sup>

**initial pulse:** Pulse applied to excite the transducer. It is the first indication on the screen if the sweep is undelayed. Also called the *main bang*. May refer to an electrical pulse or an acoustic pulse.<sup>7</sup>

**insonification:** Irradiation with sound.<sup>7</sup>

**interface:** Physical boundary between two adjacent media.<sup>7,21</sup>

**interface synchronization:** See *interface triggering*.

**interface triggering:** Triggering the sweep and auxiliary functions from an interface echo occurring after the initial pulse.<sup>7</sup> Also called *interface synchronization*.

**interpretation:** Determination of the source, significance and relevance of test indications.<sup>10</sup>

**isotropy:** Condition in which significant medium properties (sound speed, for example) are the same in all directions.<sup>7</sup>

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## L

**lamb wave:** Type of ultrasonic wave propagation in which the wave is guided between two parallel surfaces of the test object. Mode and velocity depend on the product of the test frequency and the thickness. Plate wave.<sup>7</sup>

**linearity, amplitude:** Constant proportionality between the signal input to the receiver and the amplitude of the signal appearing on the display of the ultrasonic instrument or on an auxiliary display.<sup>7,19</sup> Also called *vertical linearity*.

**linearity, area:** Constant proportionality between the signal amplitude and the areas of equal discontinuities located at the same depth in the far field. Necessarily limited by the size of the ultrasonic beam and configuration of the reflector.<sup>7</sup>

**logarithmic decrement:** Natural logarithm of the ratio of the amplitudes of two successive cycles in a damped wave train.<sup>7</sup>

**longitudinal wave:** Wave in which points of same phase lie on parallel plane surfaces.<sup>7,23</sup>

**loss of back reflection:** Absence or significant reduction of an indication from the back surface of the test object.<sup>7,21</sup>

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## M

**main bang:** See *initial pulse*.

**manipulator:** In immersion testing, a device for angular orientation of the transducer<sup>7,24</sup> and for scanning motion in three axes.

**markers:** Series of indications on the horizontal trace of the display screen to show increments of time or distance.<sup>7,21</sup>

**material noise:** Random signals caused by the material structure of the test object.<sup>7,21</sup> A component of *background noise*.

**mechanical properties:** Measurable properties of a material related to its behavior, such as toughness, hardness and elasticity. Compare *physical properties*.

**mode conversion:** Change of ultrasonic wave propagation mode upon reflection or refraction at an interface.<sup>7</sup>

**mode converted signal:** Unintended signal from mode conversion of primary test angle, due to interaction with component geometry such as the signals after back wall signal when testing a long narrow bar.

**mode of vibration:** Manner in which an acoustic wave is propagated, as characterized by the particle motion in the wave<sup>21</sup> (transverse, lamb, surface or longitudinal).<sup>7</sup>

**model, analytical:** Mathematical representation of a process or phenomenon.

**multiple back reflections:** Repetitive echoes from the far boundary of the test object.<sup>7,21</sup>

**multiple-echo technique:** Technique where thickness is measured between multiple back reflections, minimizing error from coatings or from changes in temperature or contact pressure.

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## N

**narrow band:** Relative term denoting a restricted range of frequency response.<sup>7,22</sup>

**NDC:** Nondestructive characterization.

**NDE:** (1) *Nondestructive evaluation.*  
(2) *Nondestructive examination.*

**NDI:** *Nondestructive inspection.*

**NDT:** *Nondestructive testing.*

**near field:** Distance immediately in front of a plane transducer in which the ultrasonic beam exhibits complex and changing wavefronts. Also called the *fresnel field* or *fresnel zone*.<sup>21</sup>

**neper:** Natural logarithm of a ratio of two amplitudes (equal to 8.686 dB) used as a measure of attenuation. Power ratios are expressed as half the natural logarithm.<sup>7</sup>

**nodal points:** In angle beam testing, the location of reflections at opposite surfaces as a wave progresses along a test object.<sup>7</sup>

**noise:** Undesired or unintended signals that tend to interfere with normal reception or processing of a desired signal. The origin may be an electric or acoustic source, small discontinuities or abrupt changes in the acoustic properties of the test material.<sup>7,22</sup> See also *signal-to-noise*.

**noncontact transducer:** In ultrasonic testing, a sensor designed for wave propagation through gas.

**nondestructive characterization (NDC):** Branch of nondestructive testing concerned with the description and prediction of material properties and behavior of components and systems.

**nondestructive evaluation (NDE):** Another term for nondestructive testing. In research and academic communities, the word *evaluation* is sometimes preferred because it implies interpretation by knowledgeable personnel or systems.<sup>10</sup>

**nondestructive examination (NDE):** Another term for nondestructive testing. In the utilities and nuclear industry, the word *examination* is sometimes preferred because *testing* can imply performance trials of pressure containment or power generation systems.<sup>10</sup>

**nondestructive inspection (NDI):** Another term for nondestructive testing. In some industries (utilities, aviation), the word *inspection* often implies maintenance for a component that has been in service.<sup>10</sup>

**nondestructive testing (NDT):** Determination of the physical condition of an object without affecting that object's ability to fulfill its intended function. Nondestructive test methods typically use an appropriate form of energy to determine material properties or to indicate the presence of material discontinuities (surface, internal or concealed).<sup>10</sup>

**nonrelevant indication:** See *indication, nonrelevant*.

**normal incidence:** (1) Condition in which the axis of the ultrasonic beam is perpendicular to the entry surface of the test object. (2) Condition where the angle of incidence is zero.<sup>7</sup>

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## O

**optimum frequency:** Probe frequency that provides the highest signal-to-noise ratio compatible with the detection of a specific discontinuity. Each combination of discontinuity type and material may have a different optimum frequency.<sup>7,22</sup>

**orientation:** Angular relationship of a surface, plane, discontinuity or axis to a reference plane or surface.<sup>7,21</sup>

**oscillogram:** Common term for a record or photograph of data displayed on screen.<sup>7,22</sup>

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## P

**parasitic echo:** See *spurious echo*.

**particle motion:** Movement of particles of material during wave propagation.<sup>7</sup>

**penetration, ultrasonic:** Propagation of ultrasonic energy into a material.<sup>7</sup> See also *effective penetration*.

**period:** Value of the minimum duration after which the same characteristics of a periodic waveform or a periodic feature repeat.<sup>10</sup>

**phantom:** Reference standard used to verify the performance of diagnostic ultrasound systems.<sup>7</sup>

**phase velocity:** Velocity of a single frequency continuous wave.<sup>7</sup>

**phased array:** Mosaic of transducer elements in which the timing of the elements' excitation can be individually controlled to produce certain desired effects, such as steering or focusing the beam.

**physical properties:** Nonmechanical properties such as density, electrical conductivity, heat conductivity and thermal expansion.<sup>10</sup> Compare *mechanical properties*.

**piezoelectric effect:** Ability of certain materials to convert electrical energy (voltage) into mechanical energy (stress) and vice versa.<sup>7,22</sup>

**pitch catch technique:** Ultrasonic test technique that uses two transducers, one transmitting and the other receiving on the same or opposite surface.<sup>7,21,22</sup> Also called *double-crystal technique* or *two-transducer technique*.

**plane wave:** See *longitudinal wave*.

**plate wave:** See *lamb wave*.

**point of incidence:** Point at which the axis of the sound beam leaves the wedge of an angle beam transducer and enters the test object.<sup>7,22</sup> See also *probe index*.

**poling:** Process of reorienting crystal domains in certain materials by applying a strong electric field at elevated temperatures, inducing macroscopic polarization and piezoelectric behavior.<sup>7</sup>

**presentation:** Technique used to show ultrasonic information. This may include A-scans, B-scans or C-scans, displayed on various types of recorders or display instruments.<sup>7,21</sup>

**primary reference response level:** Ultrasonic response from the basic reference reflector at the specified sound path distance, electronically adjusted to a specified percentage of full screen height.<sup>7</sup>

**probe:** See *sensor*; *transducer*.

**probe index:** Point on a transverse wave or surface wave transducer through which the emergent beam axis passes.<sup>7,23</sup> See also *point of incidence*.

**propagation:** Movement of a wave through a medium.<sup>7,21</sup>

**pulse:** Transient electrical or ultrasonic signal that has a rapid increase in amplitude to its maximum value, followed by an immediate return.<sup>16</sup>

**pulse echo technique:** Ultrasonic test technique in which discontinuities are detected by return echoes from the transmitted pulses.<sup>7</sup>

**pulse length:** Measure of pulse duration expressed in time or number of cycles.<sup>7,22</sup>

**pulse repetition frequency:** See *repetition rate*.

**pulse tuning:** Control of pulse frequency to optimize system response.<sup>7</sup>

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## Q

**qualification:** Process of demonstrating that an individual has the required amount and the required type of training, experience, knowledge and abilities.<sup>10</sup> See also *certification* and *qualified*.

**qualified:** Having demonstrated the required amount and the required type of training, experience, knowledge and abilities.<sup>10</sup> See also *certified* and *qualification*.

**quality:** Ability of a process or product to meet specifications or to meet the expectations of its users in terms of efficiency, appearance, reliability and ergonomics.<sup>10</sup>

**quality assurance:** Administrative actions that specify, enforce and verify quality.<sup>10</sup>

**quality control:** Physical and administrative actions required to ensure compliance with a quality assurance program. Quality control may include nondestructive testing in the manufacturing cycle.<sup>10</sup>

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## R

**radian (rad):** Measurement unit of plane angle subtending, in a circle, an arc equal in length to the radius.

**radio frequency display:** Presentation of unrectified signals.<sup>7,22</sup> See also *video presentation*.

**range:** Maximum ultrasonic path length that is displayed.<sup>7</sup> See also *sweep length*.<sup>22</sup>

**rarefaction:** Thinning or separation of particles in a propagating medium due to the decompression phase of an ultrasonic cycle. Opposite of compression. A compressional wave is composed of alternating compressions and rarefactions.<sup>7,21</sup>

**rayleigh wave:** Ultrasonic wave that propagates along the surface of a test object. The particle motion is elliptical in a plane perpendicular to the surface, decreasing rapidly with depth below the surface. The effective depth of penetration is considered to be about one wavelength.<sup>7</sup> Also called *surface wave*.

- receiver:** (1) Section of the ultrasonic instrument that amplifies echoes returning from the test object.  
(2) Transducer that picks up the echoes.<sup>7</sup>
- recommended practice:** Set of guidelines or recommendations.<sup>10</sup>
- Recommended Practice No. SNT-TC-1A:** Set of guidelines published by the American Society for Nondestructive Testing, for employers to establish and conduct a qualification and certification program for nondestructive testing personnel.<sup>10</sup>
- reference standard:** (1) Test object containing known reflectors representing accept or reject criteria.  
(2) Sample test object selected for reference.
- refracted beam:** Beam transmitted in the second medium when an ultrasonic beam is incident at an acute angle on the interface between two media having different sound speeds.<sup>7,22</sup>
- refraction:** Change in direction of an acoustic wave as the ultrasonic beam passes from one medium into another having different acoustic speeds. A change in both direction and mode occurs at acute angles of incidence. At small angles of incidence, the original mode and a converted mode may exist simultaneously in the second medium.<sup>7</sup>
- refractive index:** Ratio of the speed of the incident wave to that of a refracted wave. It is known as the refractive index of the second medium with respect to the first.<sup>7</sup>
- reject:** Minimize or eliminate low amplitude signals (such as electrical or material noise) so that other signals may be further amplified. This control can reduce vertical linearity.<sup>7</sup> Also called *suppression*.<sup>22</sup>
- rejection level:** Level above or below which a signal is an indication of a rejectable discontinuity.<sup>7,22</sup>
- relevant indication:** In nondestructive testing, an indication from a discontinuity requiring evaluation.<sup>7</sup>
- repetition rate:** Number of pulses generated or transmitted per unit of time (usually seconds).<sup>7</sup>
- resolving power:** Measure of the ability of an ultrasonic system to separate two signals close together in time or distance.<sup>7,21</sup>
- resonance:** Condition in which the frequency of a forcing vibration (ultrasonic wave) is the same as the natural vibration frequency of the propagation body (test object), possibly resulting in large amplitude vibrations.<sup>7,21</sup>
- resonance technique:** Method using the resonance principle for determining speed, thickness or presence of laminar discontinuities.<sup>7</sup>
- resonant frequency:** Frequency at which a body vibrates freely after being set in motion by some outside force.<sup>7,21</sup>
- RF display:** See *radio frequency display*.
- ringing signals:** (1) Closely spaced multiple signals caused by multiple reflections in a thin material.  
(2) Signals caused by continued vibration of a transducer.<sup>7,22</sup>
- ringing technique:** Test technique for bonded structures in which unbonds are indicated by increased amplitude of ringing signals.<sup>7,22</sup>
- ringing time:** Time that the mechanical vibrations of a transducer continue after the electrical pulse has stopped.<sup>7,22</sup>
- roof angle:** In a dual-element delay line transducer, the tilt angle by which the transducer elements of the delay line are oriented to direct the beams of the two elements to intersect at a specified zone in the medium.<sup>7</sup>
- 
- ## S
- SAM:** scanning acoustic microscope.
- saturation:** Condition in which high amplitude signals on a display screen do not increase with increased gain and appear flattened.<sup>7</sup>
- scanning:** Movement of the transducer over the surface of the test object in a controlled manner so as to achieve complete coverage. May be either a contact or immersion technique.<sup>7</sup>
- scattering:** Uncontrolled reflection of ultrasonic waves by small discontinuities or surface irregularities.<sup>7</sup>
- schlieren system:** Optical system used for visual display of an ultrasonic beam passing through a transparent medium.<sup>7,22</sup>
- search unit:** See *transducer*.
- self-coupling transducer:** Contact transducer that allows testing with a liquid couplant.
- send/receive transducer:** Transducer consisting of two piezoelectric elements mounted side by side separated by an acoustic barrier. One element transmits; one receives.<sup>7,21</sup>
- sensitivity:** Ability of signal to change with small changes of measured quantity.
- sensor:** Device that detects a material property or mechanical behavior (such as radiation or displacement) and converts it to an electrical signal.  
*Probe; transducer.*

**shadow:** Region in a test object that cannot be reached by ultrasonic energy traveling in a given direction. Shadows are caused by geometry or the presence of intervening large discontinuities.<sup>7</sup>

**shear wave:** See *transverse wave*.

**shoe:** Device used to adapt a straight beam transducer for use in a specific type of testing, including angle beam or surface wave tests and tests on curved surfaces.<sup>7,22</sup> See also *wedge*.

**SH wave:** *Transverse horizontal wave*.

**SI (International System of Units):** Measurement system using decimals in which the following seven units are considered basic: meter, mole, kilogram, second, ampere, kelvin and candela.<sup>10,17</sup>

**signal:** Physical quantity, such as electrical voltage, that contains information.<sup>10,20</sup>

**signal-to-noise ratio:** Ratio of signal amplitude (responses that contain information) to baseline noise amplitude (responses that contain no information). See also *noise*.<sup>10,20</sup>

**skip distance:** In angle beam tests of plate or pipe, the distance from the sound entry point to the exit point on the same surface after reflection from the back surface.<sup>7</sup> Also called *V path*.<sup>22</sup>

**Snell's law:** Physical law that defines the relationship between the angle of incidence and the angle of refraction.

**SNR:** See *signal-to-noise ratio*.

**SNT-TC-1A:** See *Recommended Practice No. SNT-TC-1A*.

**specific acoustic impedance:** Acoustic impedance in a particular test object or a defined volume of a specified material. See also *acoustic impedance; characteristic acoustic impedance*.

**specification:** Set of instructions or standards invoked by a specific customer to govern the results or performance of a specific set of tasks or products.<sup>10</sup>

**spectrum:** Amplitude distribution of frequencies in a signal.<sup>7</sup>

**spectrum response:** Amplification (gain) of a receiver over a range of frequencies.<sup>7</sup>

**spherical wave:** Wave in which points of the same phase lie on surfaces of concentric spheres.<sup>7,23</sup>

**spurious echo:** General term denoting any indication that cannot be associated with a discontinuity or boundary at the location displayed.<sup>7</sup> Also called *parasitic echo*.

**squint angle:** Angle by which the ultrasonic beam axis deviates from the probe axis.<sup>7</sup>

**squirter:** See *water column*.

**standard:** (1) Reference object used as a basis for comparison or calibration. (2) Concept established by authority, custom or agreement to serve as a model or rule in the measurement of quantity or the establishment of a practice or procedure.<sup>7,22</sup>

**standing wave:** Wave in which the energy flux is zero at all points. Such waves result from the interaction of similar waves traveling in opposite directions as when reflected waves meet advancing waves. A particular case is that of waves in a body whose thickness is an integral multiple of half-wavelengths, as in resonance testing.<sup>7,21,22</sup>

**stiffness:** Slope of curve of stress to strain, described by Young's modulus of elasticity. Compare *hardness*.

**straight beam:** Ultrasonic wave traveling normal to the test surface.<sup>7,22</sup>

**suppression:** See *reject*.

**surface wave:** See *rayleigh wave*.

**SV wave:** *Shear vertical wave*.

**sweep:** Uniform and repeated movement of a spot across the display screen to form the horizontal baseline.<sup>7</sup> Also called *time base*.

**sweep delay:** (1) Delay in time of starting the sweep after the initial pulse. (2) Control for adjusting the time.<sup>7,22</sup> Also called *time delay*.

**sweep length:** Length of time or distance represented by the horizontal baseline on an A-scan.<sup>7,22</sup>

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## T

**test surface:** Surface of the test object at which the ultrasonic energy enters or is detected.<sup>7</sup>

**threshold:** Voltage level setting of an instrument that causes it to register only signals greater or less than a specified magnitude.<sup>10,20</sup> This threshold may be adjustable, fixed or floating.<sup>16</sup>

**through-transmission technique:** Test technique in which ultrasonic energy is transmitted through the test object and received by a second transducer on the opposite side. Changes in received signal amplitude are taken as indications of variations in material continuity.<sup>7</sup>

**time base:** See *sweep*.

**time delay:** See *sweep delay*.

**time differential:** See *delta t*.

**time of flight:** Time for an acoustic wave to travel between two points. For example, the time required for a pulse to travel from the transmitter to the receiver via diffraction at a discontinuity edge or along the surface of the test object.<sup>7</sup>

**tone burst:** Wave train consisting of several cycles of the same frequency.<sup>7</sup>

**transducer:** (1) Device that converts mechanical energy to electrical output or vice versa. (2) Piezoelectric device that converts attributes of the stress-strain field of an acoustic wave into an electrical signal of voltage versus time. *Sensor; probe.*<sup>16</sup>

**transducer, differential:** Piezoelectric twin-element or dual-pole transducer, the output poles of which are isolated from the case and are at a floating potential.<sup>16</sup>

**transducer element:** In an ultrasonic *transducer*, the piezoelectric crystal to be coupled to the test surface. Also called the *crystal*.

**transducer, flat response:** Transducer whose frequency response has no resonance or characteristic response within its specified frequency band.<sup>16</sup>

**transducer relative sensitivity:** Response of the transducer to a given source.<sup>16</sup>

**transducer, resonant:** Transducer that uses the mechanical amplification due to a resonant frequency (or several close resonant frequencies) to give high sensitivity in a narrow band, typically  $\pm 10$  percent of the principal resonant frequency at the  $-3$  dB points.<sup>16</sup>

**transducer, single-ended:** Piezoelectric single-element transducer, the output pole of which is isolated from the case, the other pole being at the same potential as the case.<sup>16</sup>

**transducer, wide band:** Transducer whose response to surface displacements is flat over a wide frequency range.

**transfer function:** Description of changes to the waves arising as they propagate through the medium or, for a transducer, the relationship between the transducer output signal and the physical parameters of the acoustic wave at the transducer.<sup>16</sup>

**transmission angle:** Incident angle of a transmitted ultrasonic beam. It is zero degrees when the beam is perpendicular (normal) to the test surface.<sup>7,21</sup>

**transmission characteristics:** Test object characteristics that influence the passage of ultrasonic energy, including scattering, attenuation or surface conditions.<sup>7</sup>

**transmission technique:** See *through-transmission technique*.

**transmitter:** (1) Transducer that emits ultrasonic energy. (2) Electrical circuits that generate the signals emitted by the transducer.<sup>7</sup>

**transverse horizontal (polarized) wave:** Transverse wave in which the particle vibration is parallel to the incidence surface.<sup>7</sup>

**transverse vertical (polarized) wave:** Transverse wave in which the plane of vibration is normal to the incidence surface.<sup>7</sup>

**transverse wave:** Type of wave in which the particle motion is perpendicular to the direction of propagation.<sup>7,22</sup> Also called *shear wave*.

**transverse wave transducer:** Transducer that generates transverse waves in a test object.

**two-transducer technique:** See *pitch catch technique*.

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## U

**ultrasonic absorption:** Damping or dissipation of ultrasonic waves as they pass through a medium.<sup>7,21</sup> See also *attenuation coefficient*.

**ultrasonic spectroscopy:** Analysis of the frequency content of an acoustic wave. Generally performed mathematically using a fast fourier transform.<sup>7</sup>

**ultrasonic spectrum:** Usually the frequency range from 20 kHz to 50 MHz but may extend much higher in special applications.<sup>7</sup>

**ultrasonic:** Of or relating to acoustic vibration frequencies greater than about 20 kHz.<sup>7,22</sup>

**ultrasonic testing:** Method of nondestructive testing, using acoustic waves at inaudibly high frequencies at the interrogating energy.

**UT:** Abbreviation for the ultrasonic method of nondestructive testing.<sup>7,22</sup>

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## V

**vertical limit:** Maximum useful readable level of vertical indication on an A-scan.<sup>7</sup>

**vertical linearity:** See *linearity, amplitude*.

**video presentation:** Display presentation in which radiofrequency signals have been rectified and usually filtered.<sup>7,22</sup>

**V path:** See *skip distance*.

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## W

- water column:** Tube filled with water and attached to the front of a transducer to couple an ultrasonic beam to a test object. A delay line between the initial pulse and the front surface signal. Also serves as a coupling device.<sup>7</sup> See also *delay line*.
- water jet:** Unsupported stream of water carrying ultrasonic signals between the transducer and the test object surface.<sup>7</sup> Also called a *squirter* or *water column*.
- water path:** In immersion testing or with a water column, the distance from the transducer face to the test object's front surface.<sup>7,22</sup>
- wave interference:** Production of a series of maxima and minima of sound pressure as a consequence of the superposition of waves having different phases.<sup>7,22</sup>
- wave train:** Series of waves or groups of waves passing along the same course at regular intervals.<sup>7</sup>
- wavefront:** In a wave disturbance, the locus of points having the same phase.<sup>7,22</sup>
- waveguide:** Device to transmit elastic energy from a test object to a remote transducer — for example, a wire joined at one end to a test object and at the other end to a transducer.
- wavelength:** Distance needed in the propagation direction for a wave to go through a complete cycle.<sup>7,21</sup>
- wear face:** Protective material on the face of a transducer to prevent wear of the piezoelectric element.<sup>7,22</sup>
- wedge:** Device used to direct ultrasonic energy into a test object at an acute angle.<sup>7,22</sup> See also *shoe*.
- wheel transducer:** Device that couples ultrasonic energy to a test object through the rolling contact area of a wheel containing a liquid and one or more transducers.<sup>7,22</sup>
- wrap around:** Display of misleading ultrasonic reflections from a previously transmitted pulse because of excessive pulse repetition frequency.<sup>7,24</sup> See also *ghost*.

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## PART 2. Symbols

$c$  = speed of sound in air (meter per second)  
 $D$  = diameter (meter)  
dB = decibel  
 $E$  = Young's modulus of elasticity  
 $f$  = frequency (hertz)  
 $R, r$  = reflection coefficient  
 $T$  = transmission coefficient  
 $t$  = time (second)  
 $V$  = volt  
 $v$  = velocity (meter per second)  
 $Z$  = impedance (pascal second per meter)  
 $\alpha$  = attenuation  
 $\epsilon$  = strain  
 $\lambda$  = wavelength (meter)  
 $\theta$  = angle (radian)  
 $\rho$  = density (kilogram per cubic meter)  
 $\sigma$  = Poisson's ratio; stress (pascal)

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