



# 13

C H A P T E R

## **Acoustic Emission Testing Glossary**

---

## Introduction

Many of the definitions in this glossary are adapted from the second and third edition of the *Nondestructive Testing Handbook*.<sup>1-15</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.

## Terms

### A

**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>5</sup>

**acoustic emission activity:** Number of bursts (or events, if the appropriate conditions are fulfilled) detected during a test or part of a test.<sup>5</sup>

**acoustic emission count:** Number of times the signal amplitude exceeds the preset reference threshold.<sup>5</sup> Sometimes called *ringdown counts*.

**acoustic emission event:** Microstructural displacement that produces elastic waves in a material under load or stress.<sup>5</sup>

**acoustic emission hit:** Acoustic emission signal on one channel.

**acoustic emission rate:** Number of times the amplitude has exceeded the threshold in a specified unit of time.<sup>5</sup>

**acoustic emission signal:** Electrical signal obtained through the detection of acoustic emission.<sup>5</sup>

**AE:** Acoustic emission testing.

**analog-to-digital converter:** Circuit whose input is analog and whose output is digital.

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

**array:** Group of transducers used for source location.<sup>5</sup>

**artificial source:** Point where elastic waves are created to simulate an acoustic emission event. The term also denotes a device used to create the waves.<sup>5</sup>

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

**ASNT Recommended Practice**

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

**attenuation:** Decrease in signal amplitude over distance, often called *loss*; can be expressed in decibels.<sup>10</sup>

### B

**background noise:** Signal or signals not caused by an acoustic emission event. It has electrical, mechanical or chemical origins.<sup>5</sup>

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

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

**burst:** Signal whose oscillations have a rapid increase in amplitude from an initial reference level (generally that of the background noise), followed by a decrease (generally more gradual than the initial rise) to a value close to the initial level.<sup>5</sup>

**burst counting:** Measurement of the number of bursts detected relative to specified equipment settings such as threshold level.<sup>5</sup>

**burst duration:** Interval between the first and last time the threshold was exceeded by the burst.<sup>5</sup>

**burst emission:** Qualitative term denoting acoustic emission when bursts are observed.<sup>5</sup> Opposite of *continuous emission*.

**burst rate:** Number of bursts detected in a specified time.<sup>5</sup>

**burst rise time:** Time interval between the first threshold crossing and the maximum amplitude of the burst.<sup>5</sup>

### C

**certification:** With respect to nondestructive test personnel, process of providing written testimony that an individual is qualified. See also *certified* and *qualified*.

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

**continuous emission:** Qualitative term applied to ongoing acoustic emission in which the bursts or pulses are not individually discernible — for example, emission from a leak.

**count rate:** See *acoustic emission rate*.

**couplant:** Substance providing an acoustic link between a propagation medium and a transducer.<sup>5</sup>

**crack:** (1) Break, fissure or rupture, sometimes V shaped in cross section and relatively narrow and deep. Discontinuity that has a relatively large cross section in one direction and a small or negligible cross section when viewed in a direction perpendicular to the first.  
(2) Propagating discontinuity caused by stresses such as heat treating or grinding. 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>

**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>

**cumulative bursts:** Number of bursts detected from the beginning of a test.<sup>5</sup>

**cumulative characteristic distribution:** In acoustic emission signal processing, a display of the number of times a characteristic meets a preselected criterion.

**cumulative count:** Number of times the amplitude of the signal has exceeded the threshold since the start of the test.<sup>5</sup>

**cumulative events:** Number of events detected from the beginning of a test.

## D

**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. Twenty decibels equals ten-fold voltage amplification.

**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>10,17</sup> Note that some discontinuities may not exceed an accept/reject criterion and are therefore not defects. Compare *crack*; *discontinuity*; *indication*.<sup>10</sup>

**delta (t):** Time interval between the detected arrival of an acoustic emission wave at two sensors.<sup>5</sup> Also called *time differential* or *difference in time of arrival*.

**differential amplifier:** Amplifier whose output signal is proportional to the mathematical difference between two input signals.<sup>10,16</sup>

**discontinuity:** Interruption in the physical structure or configuration of a test object. After nondestructive testing, discontinuities can be interpreted to be *flaws* or *defects*.<sup>10</sup> See *defect* and *indication*.

**dispersion:** In acoustics, variation of wave velocity with frequency.<sup>7</sup>

## E

**event:** See *acoustic emission event*.

**event counting:** Measurement of the number of acoustic emission events.

**event rate:** Number of acoustic emission events detected in a specified unit of time.

## F

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

**felicity effect:** Appearance of significant acoustic emission at a load (or pressure) level below the previous maximum applied.<sup>5</sup>

**felicity ratio:** Measurement of the felicity effect. Defined as the ratio between (1) the applied load (or pressure) at which acoustic emission reappears during the next application of loading and (2) the previous maximum applied load.<sup>5</sup>

**filter:** (1) Electrical circuit that leaves a signal unaffected over a prescribed range of frequencies and attenuates signal components at all other frequencies.<sup>10,19</sup> (2) Data analysis process for reducing data files.

**finite element analysis:** Numerical technique for the analysis of a continuous system whereby that system is decomposed into a collection of finite sized elements.<sup>10</sup>

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

## G

**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>

**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>

## 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.

**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>10,16</sup>

**hit:** See *acoustic emission hit*.

**hit lockout time:** Time interval set to suppress late arriving parts of an acoustic emission signal.

**hsu-nielsen source:** See *pencil break source*.

## I

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

**indication, nonrelevant:** Indication due to misapplied or improper testing. May also be an indication caused by an actual discontinuity that does not affect the usability of the test object (a change of section, for instance). 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>10,18</sup>

**interpretation:** Determination of the significance of test indications according to their relevance or irrelevance.<sup>10</sup>

## K

**kaiser effect:** Absence of detectable acoustic emission until the previous maximum applied stress level has been exceeded.<sup>5</sup>

## L

**location plot:** Spatial representation of acoustic emission sources computed using an array of transducers.<sup>5</sup>

## M

**maximum burst amplitude:** Maximum signal amplitude within the duration of the burst.<sup>5</sup>

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

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

## N

**NDC:** *Nondestructive characterization*.

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

**NDI:** *Nondestructive inspection*.

**NDT:** *Nondestructive testing*.

**noise:** Undesired or unintended signal or signals.

**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>

**P**

**parameter distribution:** Display of the number of times an acoustic emission parameter falls between the values  $x$  and  $x + \delta x$  as a function of  $x$ . Typical parameters are amplitude, rise time and duration.<sup>5</sup>

**pencil break source:** Artificial source using the fracture of a brittle graphite or equivalent cylinder in a suitable fitting to simulate an acoustic emission signal.<sup>5</sup> Also called *hsu-nielson source*.

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

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

**pulse:** Electronic signal that has a rapid increase in amplitude to its maximum value, followed by an immediate return.<sup>5</sup>

**pulsar transducer:** Transducer used as an artificial source, introducing a repeatable, transient signal to calibrate and verify an acoustic emission processor.

**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>

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

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

**quality assurance:** Administrative actions that specify, enforce and verify a quality program.<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>

**R**

**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>

**recovery time:** Time required for a test system to return to its original state after overload.

**reference threshold:** Preset voltage level that has to be exceeded before an acoustic emission signal is detected and processed. This threshold may be adjustable, fixed or floating.<sup>5</sup> See also *threshold level*.

**ringdown count:** See *acoustic emission count*.

**S**

**sensor:** Device that detects a material property or mechanical behavior (such as radiation or displacement) and converts it to an electrical signal. Probe; *transducer*.

**SI (International System of Units):** Measurement system in which the following seven units are considered basic: meter, mole, kilogram, second, ampere, kelvin and candela.<sup>10,16</sup>

**signal:** Physical quantity, such as electrical voltage, that contains information.<sup>10,19</sup>

**signal-to-noise ratio:** Ratio of signal values (responses that contain information) to baseline noise values (responses that contain no information). See *noise*.<sup>10,19</sup>

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

**source, acoustic emission:** (1) Place of an acoustic emission event.<sup>5</sup> (2) Unique mechanism responsible for generation of acoustic emission.

**source location:** Determination of the location of an acoustic emission source from arrival times by using multiple transducers.

**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>

**stiffness:** Slope of stress-strain curve; Young's modulus  $E$ . *See also* hardness.

## T

**threshold level:** Setting of an instrument that causes it to register only those changes in response greater or less than a specified magnitude.<sup>10,19</sup>

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

**transducer:** (1) Device that converts mechanical energy to electrical output and vice versa. (2) Piezoelectric device that converts the physical parameters of an acoustic wave into an electrical signal of voltage versus time. *Sensor; probe.*

**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>5</sup>

**transducer, flat response:** Transducer whose frequency response has no resonance or characteristic response with its specified frequency band (the bandwidth to  $-3$  dB being defined) and the ratio between the upper and lower limits of the frequency band being typically not less than 500 kHz.<sup>5</sup>

**transducer relative sensitivity:** Response of the transducer to a given source.

**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>5</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>5</sup>

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

**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 wave at the source.<sup>5</sup>

## W

**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.

---

---

---

## References

1. *Nondestructive Testing Handbook*, second edition: Vol. 1, *Leak Testing*. Columbus, OH: American Society for Nondestructive Testing (1982).
2. *Nondestructive Testing Handbook*, second edition: Vol. 2, *Liquid Penetrant Tests*. Columbus, OH: American Society for Nondestructive Testing (1982).
3. *Nondestructive Testing Handbook*, second edition: Vol. 3, *Radiography and Radiation Testing*. Columbus, OH: American Society for Nondestructive Testing (1985).
4. *Nondestructive Testing Handbook*, second edition: Vol. 4, *Electromagnetic Testing*. Columbus, OH: American Society for Nondestructive Testing (1986).
5. *Nondestructive Testing Handbook*, second edition: Vol. 5, *Acoustic Emission Testing*. Columbus, OH: American Society for Nondestructive Testing (1987).
6. *Nondestructive Testing Handbook*, second edition: Vol. 6, *Magnetic Particle Testing*. Columbus, OH: American Society for Nondestructive Testing (1989).
7. *Nondestructive Testing Handbook*, second edition: Vol. 7, *Ultrasonic Testing*. Columbus, OH: American Society for Nondestructive Testing (1991).
8. *Nondestructive Testing Handbook*, second edition: Vol. 8, *Visual and Optical Testing*. Columbus, OH: American Society for Nondestructive Testing (1993).
9. *Nondestructive Testing Handbook*, second edition: Vol. 9, *Special Nondestructive Testing Methods*. Columbus, OH: American Society for Nondestructive Testing (1995).
10. *Nondestructive Testing Handbook*, second edition: Vol. 10, *Nondestructive Testing Overview*. Columbus, OH: American Society for Nondestructive Testing (1996).
11. *Nondestructive Testing Handbook*, third edition: Vol. 1, *Leak Testing*. Columbus, OH: American Society for Nondestructive Testing (1998).
12. *Nondestructive Testing Handbook*, third edition: Vol. 2, *Liquid Penetrant Testing*. Columbus, OH: American Society for Nondestructive Testing (2000).
13. *Nondestructive Testing Handbook*, third edition: Vol. 3, *Infrared and Thermal Testing*. Columbus, OH: American Society for Nondestructive Testing (2001).
14. *Nondestructive Testing Handbook*, third edition: Vol. 4, *Radiographic Testing*. Columbus, OH: American Society for Nondestructive Testing (2002).
15. *Nondestructive Testing Handbook*, third edition: Vol. 5, *Electromagnetic Testing*. Columbus, OH: American Society for Nondestructive Testing (2004).
16. *IEEE Standard Dictionary of Electrical and Electronic Terms*. New York, NY: Wiley-Interscience, for the Institute of Electrical and Electronics Engineers (1984).
17. API RP 5A5, *Recommended Practice for Field Inspection of New Casing, Tubing, and Plain End Drill Pipe*, sixth edition. Washington, DC: American Petroleum Institute (1999).
18. *Annual Book of ASTM Standards: Section 3, Metals Test Methods and Analytical Procedures*. Vol. 03.03, *Nondestructive Testing*. West Conshohocken, PA: ASTM International (2001).
19. ASTM E 268-81, *Definitions Approved for Use by Agencies of the Department of Defense as Part of Federal Test Method Standard No. 151b and for Listing in the DoD Index of Specifications and Standards*. West Conshohocken, PA: ASTM International (1981).

