



# Standard Terminology for Nondestructive Examinations<sup>1</sup>

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## INDEX OF TERMS

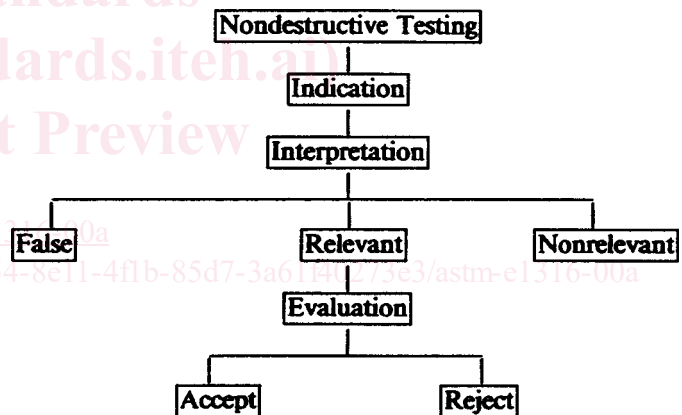
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## 1. Scope

1.1 This standard defines the terminology used in the standards prepared by the E07 Committee on Nondestructive Testing. These nondestructive testing (NDT) methods include: acoustic emission, electromagnetic testing, gamma- and X-radiology, leak testing, liquid penetrant examination, magnetic particle examination, neutron radiology and gaging, ultrasonic examination, and other technical methods.

1.2 Section A defines terms that are common to multiple NDT methods, whereas, the subsequent sections define terms pertaining to specific NDT methods. An alphabetical list of the terms defined in this standard is given in Appendix X1, which also identifies the section in which each term is defined.

1.3 As shown on the chart below, when nondestructive testing produces an indication, the indication is subject to interpretation as false, nonrelevant or relevant. If it has been interpreted as relevant, the necessary subsequent evaluation will result in the decision to accept or reject the material. With the exception of accept and reject, which retain the meaning found in most dictionaries, all the words used in the chart are defined in Section A.



## 2. Referenced Documents

### 2.1 ASTM Standards:

- E 94 Guide for Radiographic Testing<sup>2</sup>
- E 127 Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks<sup>2</sup>
- E 215 Practice for Standardizing Equipment for Electromagnetic Examination of Seamless Aluminum-Alloy Tube<sup>2</sup>
- E 494 Practice for Measuring Ultrasonic Velocity in Materials<sup>2</sup>
- E 566 Practice for Electromagnetic (Eddy-Current) Sorting of Ferrous Metals<sup>2</sup>

<sup>1</sup> This terminology is under the jurisdiction of Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.92 on Editorial Review.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 03.03.

- E 664 Practice for Measurement of the Apparent Attenuation of Longitudinal Ultrasonic Waves by Immersion Method<sup>2</sup>
- E 750 Practice for Characterizing Acoustic Emission Instrumentation<sup>2</sup>
- E 804 Practice for Calibration of the Ultrasonic Test System by Extrapolation Between Flat Bottom Hole Sizes<sup>3</sup>
- E 1033 Practice for Electromagnetic (Eddy-Current) Examination of Type F-Continuously Welded (CW) Ferromagnetic Pipe and Tubing Above the Curie Temperature<sup>2</sup>

<sup>3</sup> Discontinued. See 1993 *Annual Book of ASTM Standards*, Vol 03.03.

- E 1067 Practice for Acoustic Emission Examination of Fiberlass Reinforced Plastic Resin (FRP) Tanks/Vessels<sup>2</sup>
- E 1118 Practice for Acoustic Emission Examination of Reinforced Thermosetting Resin Pipe (RTRP)<sup>2</sup>
- E 1213 Test Method for Minimum Resolvable Temperature Difference for Thermal Imaging Systems<sup>2</sup>

### 3. Significance and Use

3.1 The terms found in this proposed standard are intended to be used uniformly and consistently in all nondestructive testing standards. The purpose of this standard is to promote a clear understanding and interpretation of the NDT standards in which they are used.

## Section A: Common NDT Terms

The terms defined in Section A are the direct responsibility of Subcommittee E07.92, Editorial Review.

### 4. Terminology

**acceptable quality level**—the maximum percent defective or the maximum number of units defective per hundred units that, for the purpose of sampling test, can be considered satisfactory as a process average.

**amorphous silicon ( $\alpha$ -Si) X-ray detector**, *n*—an amorphous silicon ( $\alpha$ -Si) X-ray detector consists of a glass substrate with a matrix of photodiodes fabricated from amorphous silicon and switches arranged in rows and columns upon it; the photodiodes are activated by light photons emitted from a scintillator which is activated by X rays and is usually in close contact with the diode matrix.

**calibration, instrument**, *n*—the comparison of an instrument with, or the adjustment of an instrument to, a known reference(s) often traceable to the National Institute of Standards and Technology (NIST). (See also **standardization, instrument**.)

**defect**, *n*—one or more flaws whose aggregate size, shape, orientation, location, or properties do not meet specified acceptance criteria and are rejectable.

**discontinuity**, *n*—a lack of continuity or cohesion; an intentional or unintentional interruption in the physical structure or configuration of a material or component.

**evaluation**—a review, following interpretation of the indications noted, to determine whether they meet specified acceptance criteria.

**examination**, *n*—a procedure for determining a property (or properties) or other conditions or characteristics of a material or component by direct or indirect means.

**DISCUSSION**—Examples include utilization of X rays or ultrasonic waves for the purpose of determining (directly or by calculation) flaw content, density, or (for ultrasound) modulus; or detection of flaws by induction of eddy currents, observing thermal behavior, AE response, or utilization of magnetic particles or liquid penetrants.

**false indication**, *n*—an NDT indication that is interpreted to be caused by a condition other than a discontinuity or imperfection.

**flaw**, *n*—an imperfection or discontinuity that may be detectable by nondestructive testing and is not necessarily rejectable.

**flaw characterization**, *n*—the process of quantifying the size, shape, orientation, location, growth, or other properties, of a flaw based on NDT response.

**imperfection**, *n*—a departure of a quality characteristic from its intended condition.

**indication**—the response or evidence from a nondestructive examination.

**DISCUSSION**—An indication is determined by interpretation to be relevant, non-relevant, or false.

**inspection**, *n*—a procedure for viewing or observing visual characteristics of a material or component in a careful, critical manner.

**DISCUSSION**—Examples include performance of a visual/optical inspection, observing the results of a magnetic particle or liquid penetrant examination, or carefully observing a surface condition prior to performing an ultrasonic or eddy-current examination. (From the same root word as “spectacle” or “spectator”.)

**interpretation**—the determination of whether indications are relevant or nonrelevant.

**interpretation**, *n*—the determination of whether indications are relevant, nonrelevant, or false.

**Nondestructive Evaluation**—see *Nondestructive Testing*.

**Nondestructive Examination**—see *Nondestructive Testing*.

**Nondestructive Inspection**—see *Nondestructive Testing*.

**Nondestructive Testing (NDT)**, *n*—the development and application of technical methods to examine materials or components in ways that do not impair future usefulness and serviceability in order to detect, locate, measure and evaluate flaws; to assess integrity, properties and composition; and to measure geometrical characteristics.

**nonrelevant indication**, *n*—an NDT indication that is caused by a condition or type of discontinuity that is not rejectable. False indications are non-relevant.

**relevant indication**, *n*—an NDT indication that is caused by a condition or type of discontinuity that requires evaluation.

**standardization, instrument**, *n*—the adjustment of an instrument, prior to use, to an arbitrary reference value. (See also **calibration, instrument**.)

**test**, *n*—a procedure for determining a property or characteristic of a material or a component by direct measurement.

DISCUSSION—Examples include mechanical tests to determine strength, hardness, or other property; determination of leakage (a leak test); or checking the performance (function) of a piece of equipment.

### Section B: Acoustic Emission (E 750, E 1067, and E 1118)

The boldface designations in parentheses indicate the standards from which the terms in that section were derived. The terms defined in Section B are the direct responsibility of Subcommittee E07.04 on Acoustic Emission Method.

**acoustic emission (AE)**—the class of phenomena whereby transient elastic waves are generated by the rapid release of energy from localized sources within a material, or the transient waves so generated. Acoustic emission is the recommended term for general use. Other terms that have been used in AE literature include (1) stress wave emission, (2) microseismic activity, and (3) emission or acoustic emission with other qualifying modifiers.

*acoustic emission channel*—see **channel, acoustic emission**.

*acoustic emission count (emission count) (N)*—see **count, acoustic emission**.

*acoustic emission count rate*—see **count rate, acoustic emission (emission rate or count rate) ( $\dot{N}$ )**.

*acoustic emission event*—see **event, acoustic emission**.

*acoustic emission event energy*—see **energy, acoustic event**.

*acoustic emission sensor*—see **sensor, acoustic emission**.

*acoustic emission signal amplitude*—see **signal amplitude, acoustic emission**.

*acoustic emission signal (emission signal)*—see **signal, acoustic emission**.

*acoustic emission signature (signature)*—see **signature, acoustic emission**.

*acoustic emission transducer*—see **sensor, acoustic emission**.

*acoustic emission waveguide*—see **waveguide, acoustic emission**.

**acousto-ultrasonics (AU)**—a nondestructive examination method that uses induced stress waves to detect and assess diffuse defect states, damage conditions, and variations of mechanical properties of a test structure. The AU method combines aspects of acoustic emission (AE) signal analysis with ultrasonic materials characterization techniques.

**adaptive location**—source location by iterative use of simulated sources in combination with computed location.

**AE activity,  $n$** —the presence of acoustic emission during a test.

**AE rms,  $n$** —the rectified, time averaged AE signal, measured on a linear scale and reported in volts.

**AE signal duration**—the time between AE signal start and AE signal end.

**AE signal end**—the recognized termination of an AE signal, usually defined as the last crossing of the threshold by that signal.

**AE signal generator**—a device which can repeatedly induce a specified transient signal into an AE instrument.

**AE signal rise time**—the time between AE signal start and the peak amplitude of that AE signal.

**AE signal start**—the beginning of an AE signal as recognized by the system processor, usually defined by an amplitude

excursion exceeding threshold.

**array,  $n$** —a group of two or more AE sensors positioned on a structure for the purposes of detecting and locating sources. The sources would normally be within the array.

*arrival time interval ( $\Delta t_{ij}$ )*—see **interval, arrival time**.

**attenuation,  $n$** —the decrease in AE amplitude per unit distance, normally expressed in dB per unit length.

**average signal level,  $n$** —the rectified, time averaged AE logarithmic signal, measured on the AE amplitude logarithmic scale and reported in dB<sub>ae</sub> units (where 0 dB<sub>ae</sub> refers to 1  $\mu$ V at the preamplifier input).

*burst emission*—see **emission, burst**.

**channel, acoustic emission**—an assembly of a sensor, preamplifier or impedance matching transformer, filters secondary amplifier or other instrumentation as needed, connecting cables, and detector or processor.

DISCUSSION—A channel for examining fiberglass reinforced plastic (FRP) may utilize more than one sensor with associated electronics. Channels may be processed independently or in predetermined groups having similar sensitivity and frequency characteristics.

*continuous emission*—see **emission, continuous**.

**count, acoustic emission (emission count) (N)**—the number of times the acoustic emission signal exceeds a preset threshold during any selected portion of a test.

**count, event ( $N_e$ )**—the number obtained by counting each discerned acoustic emission event once.

**count rate, acoustic emission (emission rate or count rate) ( $\dot{N}$ )**—the time rate at which emission counts occur.

*count, ring-down*—see **count, acoustic emission**, the preferred term.

**couplant**—a material used at the structure-to-sensor interface to improve the transmission of acoustic energy across the interface during acoustic emission monitoring.

*cumulative (acoustic emission) amplitude distribution  $F(V)$* —see **distribution, amplitude, cumulative**.

*cumulative (acoustic emission) threshold crossing distribution  $F_t(V)$* —see **distribution, threshold crossing, cumulative**.

**dB<sub>AE</sub>**—a logarithmic measure of acoustic emission signal amplitude, referenced to 1  $\mu$ V.

$$\text{Signal peak amplitude (dB}_{AE}) = 20 \log_{10}(A_1/A_0) \quad (1)$$

where:

$A_0$  = 1  $\mu$ V at the sensor output (before amplification), and  
 $A_1$  = peak voltage of the measured acoustic emission signal.

Acoustic Emission Reference Scale:

dB <sub>AE</sub> Value	Voltage at Sensor Output
0	1 μV
20	10 μV
40	100 μV
60	1 mV
80	10 mV
100	100 mV

**dead time**—any interval during data acquisition when the instrument or system is unable to accept new data for any reason. (E 750)<sup>4</sup>

**differential (acoustic emission) amplitude distribution  $F(V)$** —see **distribution, differential (acoustic emission) amplitude  $f(V)$** .

**differential (acoustic emission) threshold crossing distribution  $f_t(V)$** —see **distribution, differential (acoustic emission) threshold crossing**.

**distribution, amplitude, cumulative (acoustic emission)  $F(V)$** —the number of acoustic emission events with signals that exceed an arbitrary amplitude as a function of amplitude  $V$ .

**distribution, threshold crossing, cumulative (acoustic emission)  $F_t(V)$** —the number of times the acoustic emission signal exceeds an arbitrary threshold as a function of the threshold voltage ( $V$ ).

**distribution, differential (acoustic emission) amplitude  $f(V)$** —the number of acoustic emission events with signal amplitudes between amplitudes of  $V$  and  $V + \Delta V$  as a function of the amplitude  $V$ .  $f(V)$  is the absolute value of the derivative of the cumulative amplitude distribution  $F(V)$ .

**distribution, differential (acoustic emission) threshold crossing  $f_t(V)$** —the number of times the acoustic emission signal waveform has a peak between thresholds  $V$  and  $V + \Delta V$  as a function of the threshold  $V$ .  $f_t(V)$  is the absolute value of the derivative of the cumulative threshold crossing distribution  $F_t(V)$ .

**distribution, logarithmic (acoustic emission) amplitude  $g(V)$** —the number of acoustic emission events with signal amplitudes between  $V$  and  $\alpha V$  (where  $\alpha$  is a constant multiplier) as a function of the amplitude. This is a variant of

the differential amplitude distribution, appropriate for logarithmically windowed data.

**dynamic range**—the difference, in decibels, between the overload level and the minimum signal level (usually fixed by one or more of the noise levels, low-level distortion, interference, or resolution level) in a system or sensor.

**effective velocity,  $n$** —velocity calculated on the basis of arrival times and propagation distances determined by artificial AE generation; used for computed location.

**emission, burst**—a qualitative description of the discrete signal related to an individual emission event occurring within the material.

NOTE 1—Use of the term burst emission is recommended only for describing the qualitative appearance of emission signals. Fig. 1 shows an oscilloscope trace of burst emission signals on a background of continuous emission.

**emission, continuous**—a qualitative description of the sustained signal level produced by rapidly occurring acoustic emission from structural sources, leaks, or both.

NOTE 2— Use of the term *continuous emission* is recommended only for describing the qualitative appearance of emission signals. Fig. 2 and Fig. 3 show oscilloscope traces of continuous emission signals at two different sweep rates.

**energy, acoustic emission event**—the total elastic energy released by an emission event.

**energy, acoustic emission signal**—the energy contained in a detected acoustic emission burst signal, with units usually reported in joules and values which can be expressed in logarithmic form (dB, decibels).

**evaluation threshold**—a threshold value used for analysis of the examination data. Data may be recorded with a *system examination threshold* lower than the *evaluation threshold*. For analysis purposes, dependence of measured data on the *system examination threshold* must be taken into consideration.

**event, acoustic emission (emission event)**—a local material change giving rise to acoustic emission.

**event count ( $Ne$ )**—see **count, event**.

**event count rate ( $\dot{N}e$ )**—see **rate, event count**.

**examination area**—that portion of a structure being monitored with acoustic emission.

<sup>4</sup> The designations in parentheses following the terms indicate the ASTM standards from which the terms were derived.

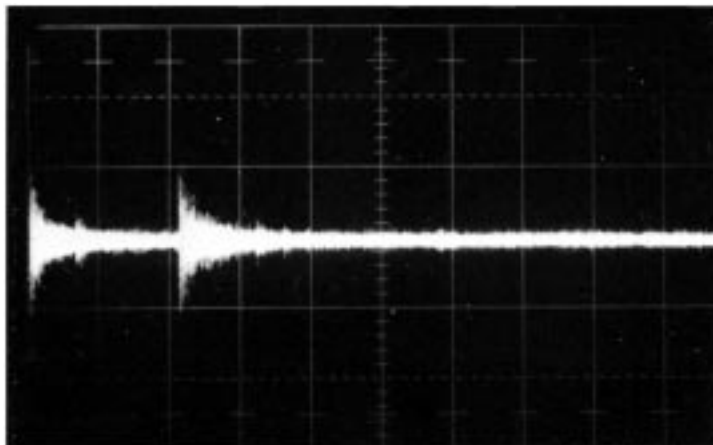


FIG. 1 Burst Emission on a Continuous Emission Background. (Sweep Rate—5 ms/cm.)



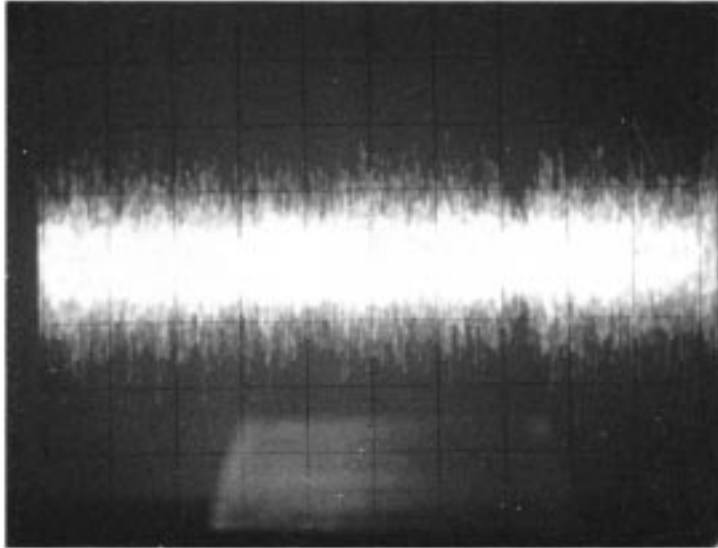


FIG. 2 Continuous Emission. (Sweep Rate—5 ms/cm.)

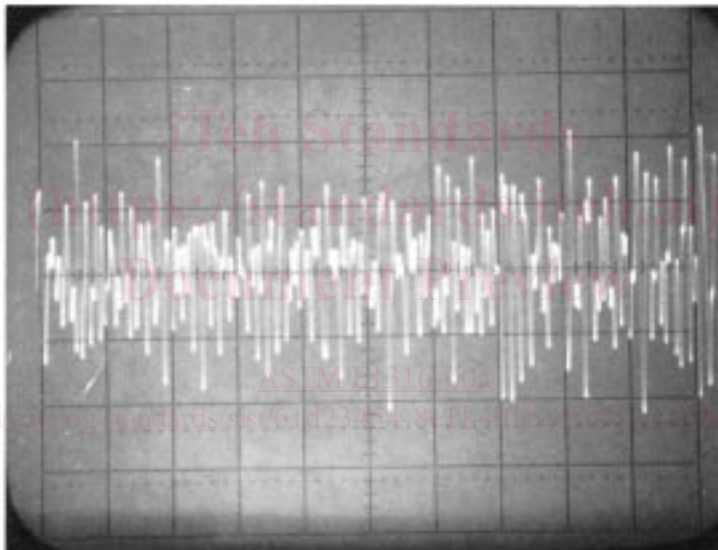


FIG. 3 Continuous Emission. (Sweep Rate—0.1 ms/cm.)

**examination region**—that portion of the test article evaluated using acoustic emission technology.

**Felicity effect**—the presence of acoustic emission, detectable at a fixed predetermined sensitivity level at stress levels below those previously applied. (E 1067)

**Felicity effect**—the presence of detectable acoustic emission at a fixed predetermined sensitivity level at stress levels below those previously applied.

**Felicity ratio**—the ratio of the stress at which the Felicity effect occurs to the previously applied maximum stress. (E 1067, E 1118)

NOTE 3—The fixed sensitivity level will usually be the same as was used for the previous loading or test. (E 1118)

**instrumentation dead time**—see **dead time, instrumentation**.

**first hit location**—a zone location method defined by which a channel among a group of channels first detects the signal.

**floating threshold**—any threshold with amplitude established

by a time average measure of the input signal. (E 750)

**hit**—the detection and measurement of an AE signal on a channel.

**interval, arrival time ( $\Delta t_{ij}$ )**—the time interval between the detected arrivals of an acoustic emission wave at the *i*th and *j*th sensors of a sensor array.

**Kaiser effect**—the absence of detectable acoustic emission at a fixed sensitivity level, until previously applied stress levels are exceeded.

**location accuracy, *n***—a value determined by comparison of the actual position of an AE source (or simulated AE source) to the computed location.

**location, cluster, *n***—a location technique based upon a specified amount of AE activity located within a specified length or area, for example: 5 events within 12 linear inches or 12 square inches.

**location, computed, *n***—a source location method based on

algorithmic analysis of the difference in arrival times among sensors.

DISCUSSION—Several approaches to computed location are used, including linear location, planar location, three dimensional location, and adaptive location.

- (a) *linear location, n*—one dimensional source location requiring two or more channels.
- (b) *planar location, n*—two dimensional source location requiring three or more channels.
- (c) *3D location, n*— three dimensional source location requiring five or more channels.
- (d) *adaptive location, n*—source location by iterative use of simulated sources in combination with computed location.

**location, continuous AE signal, n**—a method of location based on continuous AE signals, as opposed to hit or difference in arrival time location methods.

DISCUSSION—This type of location is commonly used in leak location due to the presence of continuous emission. Some common types of continuous signal location methods include signal attenuation and correlation analysis methods.

- (a) *signal attenuation-based source location, n*—a source location method that relies on the attenuation versus distance phenomenon of AE signals. By monitoring the AE signal magnitudes of the continuous signal at various points along the object, the source can be determined based on the highest magnitude or by interpolation or extrapolation of multiple readings.
- (b) *correlation-based source location, n*—a source location method that compares the changing AE signal levels (usually waveform based amplitude analysis) at two or more points surrounding the source and determines the time displacement of these signals. The time displacement data can be used with conventional hit based location techniques to arrive at a solution for the source site.

**location, source, n**—any of several methods of evaluating AE data to determine the position on the structure from which the AE originated. Several approaches to source location are used, including zone location, computed location, and continuous location.

**location, zone, n**—any of several techniques for determining the general region of an acoustic emission source (for example, total AE counts, energy, hits, and so forth).

DISCUSSION—Several approaches to zone location are used, including independent channel zone location, first hit zone location, and arrival sequence zone location.

- (a) *independent channel zone location, n*—a zone location technique that compares the gross amount of activity from each channel.
- (b) *first-hit zone location, n*—a zone location technique that compares only activity from the channel first detecting the AE event.
- (c) *arrival sequence zone location, n*—a zone location technique that compares the order of arrival among sensors.

*logarithmic (acoustic emission) amplitude distribution g(V)*—see **distribution, logarithmic (acoustic emission) amplitude**.

**overload recovery time**—an interval of nonlinear operation of an instrument caused by a signal with amplitude in excess of the instrument's linear operating range.

**pressure, design**—pressure used in design to determine the required minimum thickness and minimum mechanical properties.

**processing capacity**—the number of hits that can be processed at the processing speed before the system must interrupt data collection to clear buffers or otherwise prepare for accepting additional data.

**processing speed**—the sustained rate (hits/s), as a function of the parameter set and number of active channels, at which AE signals can be continuously processed by a system without interruption for data transport.

**rate, event count (Ñe)**—the time rate of the event count.

*rearm delay time*—see **time, rearm delay**.

*ring-down count*—see **count, acoustic emission, the preferred term**.

**sensor, acoustic emission**—a detection device, generally piezoelectric, that transforms the particle motion produced by an elastic wave into an electrical signal.

**signal, acoustic emission (emission signal)**—an electrical signal obtained by detection of one or more acoustic emission events.

**signal amplitude, acoustic emission**—the peak voltage of the largest excursion attained by the signal waveform from an emission event.

**signal overload level**—that level above which operation ceases to be satisfactory as a result of signal distortion, overheating, or damage.

**signal overload point**—the maximum input signal amplitude at which the ratio of output to input is observed to remain within a prescribed linear operating range.

**signature, acoustic emission (signature)**—a characteristic set of reproducible attributes of acoustic emission signals associated with a specific test article as observed with a particular instrumentation system under specified test conditions.

**stimulation**—the application of a stimulus such as force, pressure, heat, etc., to a test article to cause activation of acoustic emission sources.

**system examination threshold**—the electronic instrument threshold (see **evaluation threshold**) which data will be detected.

*transducers, acoustic emission*—see **sensor, acoustic emission**.

**verification, AE system**—The process of testing an AE system to assure conformance to a specified level of performance or measurement accuracy. (This is usually carried out prior to, during and/or after an AE examination with the AE system connected to the examination object, using a simulated or artificial acoustic emission source.)

**voltage threshold**—a voltage level on an electronic comparator such that signals with amplitudes larger than this level will be recognized. The voltage threshold may be user adjustable, fixed, or automatic floating. (E 750)

**waveguide, acoustic emission**—a device that couples elastic energy from a structure or other test object to a remotely mounted sensor during AE monitoring. An example of an acoustic emission waveguide would be a solid wire of rod that is coupled at one end to a monitored structure, and to a sensor at the other end.

### Section C: Electromagnetic Testing (E 215, E 243, E 566, E 1033)

The terms defined in Section C are the direct responsibility of Subcommittee E07.07 on Electromagnetic Methods.

- absolute coil**—a coil (or coils) that respond(s) to the total detected electric or magnetic properties, or both, of a part or section of the test part without comparison to another section of the part or to another part. (E 566)
- absolute measurements**—in electromagnetic testing, measurements made without a direct reference using an absolute coil in contrast to differential and comparative measurements. (See also **absolute coil**).
- absolute readout**—in electromagnetic testing, the signal output of an absolute coil. (See also **absolute coil**).
- absolute system**—a system that uses a coil assembly and associated electronics to measure the total electromagnetic properties of a test part without direct comparison to another section of the part or to another part (see **absolute coil**). (E 566)
- acceptance level**—a test level above or below which test specimens are acceptable in contrast to rejection level.
- acceptance limits**—test levels used in electromagnetic sorting which establish the group into which the material under test belongs. (E 566)
- acceptance standard**—a tube with artificial discontinuities specified in the applicable product standard used to establish the acceptance level. (E 215)
- acceptance standard**—in tubing inspection, a tube used to establish the acceptance level with artificial discontinuities as specified in the applicable product standard.
- amplitude distortion**—same as **harmonic distortion**.
- amplitude response**—that property of a test system whereby the amplitude of the detected signal is measured without regard to phase. (See also **harmonic analysis and phase analysis**.)
- annular coil clearance**—the mean radial distance between adjacent coil assembly and test part surface in electromagnetic encircling coil examination.
- annular coils**—see **encircling coils**.
- artificial discontinuity**—reference discontinuities, such as holes, grooves, or notches that are introduced into a reference standard to provide accurately reproducible sensitivity levels for electromagnetic test equipment.
- band pass filter**—a wave filter having a single transmission band; neither of the cut-off frequencies being zero or infinity.
- bobbin coil**—see **ID coil**.
- bucking coils**—same as **differential coils**.
- circumferential coils**—see **encircling coils**.
- coil, absolute**—see **absolute coil**.
- coil, reference**—see **reference coil**.
- coil size**—the dimension of a coil, for example, length or diameter.
- coil spacing**—in electromagnetic testing, the axial distance between two encircling coils of a differential system.
- coil, test**—in electromagnetic testing, the section of the probe or coil assembly that excites and /or detects the electromagnetic field in the material under test.
- comparative measurements**—in electromagnetic testing, measurements made in which the unbalance in the system is measured using comparator coils in contrast to differential and absolute measurements. (See also **comparator coils**).
- comparative readout**—in electromagnetic testing, the signal output of comparator coils. (See also **comparator coils**).
- comparative system**—a system that uses coil assemblies and associated electronics to detect any electric or magnetic condition, or both, that is not common to the test specimen and the standard (see **comparator coils**). (E 566)
- comparator coils**—in electromagnetic testing, two or more coils electrically connected in series opposition but arranged so that there is no mutual induction (coupling) between them such that any electric or magnetic condition, or both, that is not common to the test specimen and the standard, will produce an unbalance in the system and thereby yield an indication.
- conductivity**—the intrinsic property of a particular material to carry electric current; it is commonly expressed in percent IACS (International Annealed Copper Standard) or MS/m (MegaSiemens/meter).
- coupling**—two electric circuits are said to be coupled to each other when they have an impedance in common so that a current in one causes a voltage in the other.
- cut-off level**—same as **rejection level**.
- defect resolution**—a property of a test system that enables the separation of indications due to defects in a test specimen that are located in close proximity to each other.
- depth of penetration**—in electromagnetic testing, the depth at which the magnetic field strength or intensity of induced eddy currents has decreased to 37 % of its surface value. The depth of penetration is an exponential function of the frequency of the signal and the conductivity and permeability of the material. Synonymous terms are standard depth of penetration and skin depth. (See also **skin effect**.)
- diamagnetic material**—a material whose relative permeability is less than unity.
- NOTE 4—The intrinsic induction  $B_i$  is oppositely directed to the applied magnetizing force  $H$ .
- differential coils**—two or more coils electrically connected in series opposition such that any electric or magnetic condition, or both, that is not common to the areas of a specimen being electromagnetically tested will produce an unbalance in the system and thereby yield an indication.
- differential measurements**—in electromagnetic testing, measurements made in which the imbalance in the system is measured using differential coils in contrast to absolute and comparative measurements. (See also **differential coils**).
- differential readout**—in electromagnetic testing, the signal output of differential coils. (See also **differential coils**).
- differential signal**—in electromagnetic testing, an output signal that is proportional to the rate of change of the input signal.
- differential system**—an electromagnetic testing system that uses coil assemblies and associated electronics to detect an electric or magnetic condition, or both, that is not common



- to the areas of the specimen being tested. (See also **differential coils**).
- eddy current**—an electrical current caused to flow in a conductor by the time or space variation, or both, of an applied magnetic field.
- eddy current testing**—a nondestructive testing method in which eddy current flow is induced in the test object. Changes in the flow caused by variations in the specimen are reflected into a nearby coil, coils, or Hall effect device for subsequent analysis by suitable instrumentation and techniques.
- edge effect**—in electromagnetic testing, the disturbance of the magnetic field and eddy-currents due to the proximity of an abrupt change in specimen geometry (edge). This effect generally results in the masking of discontinuities within the affected region. (This effect is also termed the **end effect**.)
- effective depth penetration (EDP)**—in electromagnetic testing, for (a) thickness, the minimum depth beyond which a test system can no longer reliably detect a further increase in specimen thickness, or (b) defects, the limit for reliably detecting metallurgical or mechanical discontinuities by way of conventional continuous wave (CW) eddy current instrumentation and sensors. The EDP point is approximately three times the standard depth of penetration.
- effective permeability**—a hypothetical quantity that describes the magnetic permeability that is experienced under a given set of physical conditions such as a cylindrical test specimen in an encircling coil at a specific test frequency. This quantity may be different from the permeability of the particular metal being tested in that it takes into account such things as the geometry of the part, the relative position of the encircling coil, and characteristics of the magnetic field.
- electrical center**—the center established by the electromagnetic field distribution within a test coil. A constant intensity signal, irrespective of the circumferential position of a discontinuity, is indicative of electrical centering. The electrical center may be different from the physical center of the test coil.
- electromagnetic testing**—a nondestructive test method for materials, including magnetic materials, that uses electromagnetic energy having frequencies less than those of visible light to yield information regarding the quality of testing material.
- encircling coils**—in electromagnetic testing, coil(s) or coil assembly that surround(s) the part to be tested. Coils of this type are also referred to as annular, circumferential, or feed-through coils.
- end effect*—see **edge effect**.
- end effect**—the loss in sensitivity to discontinuities located near the extreme ends of the tube as the ends of the tube enter or leave the test coil. (E 215)
- feed-through coils*—see **encircling coils**.
- ferromagnetic material**—a material that, in general, exhibits the phenomena of magnetic hysteresis and saturation, and whose permeability is dependent on the magnetizing force.
- fill factor**—for internal probe electromagnetic testing, the ratio of the effective cross-sectional area of the primary internal probe coil to the cross-sectional area of the tube interior.
- fill factor**—for encircling coil electromagnetic testing, the ratio of the cross-sectional area of the test specimen to the effective cross-sectional core area of the primary encircling coil (outside diameter of coil form, not inside diameter which is adjacent to specimen.)
- filter**—a network that passes electromagnetic wave energy over a described range of frequencies and attenuates energy at all other frequencies.
- frequency**—the number of cycles per second of alternating electric current induced into the tubular product. For eddy-current testing described herein, the frequency is normally 1 to 125 kHz, inclusive. (E 215)
- gate*—same as **rejection level**.
- harmonic analysis**—an analytical technique whereby the amplitude or phase, or both, of the frequency components of a complex periodic signal is determined.
- harmonic distortion**—nonlinear distortion characterized by the appearance in the output of harmonics other than the fundamental component when the input wave is sinusoidal.
- IACS**—the International Annealed Copper Standard; an international standard of electrical conductivity.
- ID coil**—a coil or coil assembly used for electromagnetic testing by insertion into the test piece as in the case of an inside probe for tubing. Coils of this type are also referred to as inside coils, inserted coils, or bobbin coils.
- impedance**—the total opposition that a circuit presents to the flow of an alternating current, specifically the complex quotient of voltage divided by current.
- impedance analysis**—in electromagnetic testing, an analytical method that consists of correlating changes in the amplitude, phase, or quadrature components, or all of these, of a complex test signal voltage to the electromagnetic conditions within the test specimen.
- impedance plane diagram**—a graphical representation of the locus of points, indicating the variations in the impedance of a test coil as a function of basic test parameters.
- incremental permeability**—the ratio of the change in magnetic induction to the corresponding change in magnetizing force when the mean induction differs from zero.
- indications**—eddy-current signals caused by any change from uniformity of a tube. These changes from uniformity affect the electrical characteristic of the tube but may not be detrimental to the end use of the product. (E 215)
- initial permeability**—the slope of the induction curve at zero magnetizing force as the test specimen is being removed from a demagnetizing condition (slope at origin of BH curve before hysteresis is observed).
- inserted coil*—see **ID coil**.
- inside coil*—see **ID coil**.
- lift-off effect**—the effect observed in an electromagnetic test system output due to a change in magnetic coupling between a test specimen and a probe coil whenever the distance between them is varied.
- magnetic history**—magnetic condition of a ferromagnetic part under test based on previous exposures to magnetic fields. (E 566)
- magnetic leakage flux**—the excursion of magnetic lines of force from the surface of a test specimen.



**magnetic saturation**—that degree of magnetization where a further increase in magnetizing force produces no significant increase in magnetic flux density (permeability) in a specimen.

**modulation analysis**—an analytical method used in electromagnetic testing that separates responses due to various factors influencing the total magnetic field by separating and interpreting, individually, frequencies or frequency bands in the modulation envelope of the (carrier frequency) signal.

**noise**—in electromagnetic inspection, any nonrelevant signal that tends to interfere with the normal reception or processing of a desired flaw signal. It should be noted that such noise signals may be generated by inhomogeneities in the inspected part that are not detrimental to the end use of the part.

**nonferromagnetic material**—a material that is not magnetizable and hence, essentially not affected by magnetic fields. This would include paramagnetic materials and diamagnetic materials.

**normal permeability**—the ratio of the induction (when cyclically made to change symmetrically about zero) to the corresponding change in magnetizing force.

**off-line testing**—eddy current tests conducted on equipment that includes the test coil and means to propel individual tubes under test through the coil at appropriate speeds and conditions.

**on-line testing**—eddy current tests conducted on equipment that includes the test coil and means to propel tubes under test through the coil at appropriate speeds and conditions as an integral part of a continuous tube manufacturing sequence.

**optimum frequency**—in electromagnetic testing, that frequency which provides the largest signal-to-noise ratio obtainable for the detection of an individual material property. Each property of a given material may have its own optimum frequency.

**paramagnetic material**—a material that has a relative permeability slightly greater than unity and that is practically independent of the magnetizing force.

**permeability, a-c**—a generic term used to express various dynamic relationships between magnetic induction,  $B$ , and magnetizing force,  $H$ , for magnetic material subjected to a cyclic excitation by alternating or pulsating current. The values of a-c permeability obtained for a given material depend fundamentally upon the excursion limits of dynamic excitation and induction, the method and conditions of measurement, and also upon such factors as resistivity, thickness of laminations, frequency of excitation, etc.

DISCUSSION—The numerical value for any permeability is meaningless unless the corresponding  $B$  or  $H$  excitation level is specified. For incremental permeabilities not only must the corresponding d-c  $B$  or  $H$  excitation level be specified, but also the dynamic range ( $\Delta B$  or  $\Delta H$ ).

**permeability, d-c**—permeability is a general term used to express relationships between magnetic induction,  $B$ , and magnetizing force,  $H$ , under various conditions of magnetic excitation. These relationships are either (1) absolute permeability, which in general is the quotient of a change in magnetic induction divided by the corresponding change in

magnetizing force, or (2) relative permeability, which is the ratio of the absolute permeability to the magnetic constant ( $\gamma_m$ ).

DISCUSSION—The magnetic constant  $\gamma_m$  is a scalar quantity differing in value and uniquely determined by each electromagnetic system of units. In the unrationalized cgs system  $\gamma_m$  is 1 gauss/oersted and the mksa rationalized system  $\gamma_m = 4\pi \times 10^{-7}$  H/m.

DISCUSSION—Relative permeability is a pure number which is the same in all unit systems. The value and dimension of absolute permeability depends on the system of units employed.

DISCUSSION—For any ferromagnetic material, permeability is a function of the degree of magnetization. However, initial permeability,  $\mu_o$ , and maximum permeability,  $\mu_m$ , are unique values for a given specimen under specified conditions.

DISCUSSION—Except for initial permeability,  $\mu_o$ , a numerical value for any of the d-c permeabilities is meaningless unless the corresponding  $B$  or  $H$  excitation level is specified.

DISCUSSION—For the incremental permeabilities  $\mu\Delta$  and  $\mu\Delta i$ , a numerical value is meaningless unless both the corresponding values of mean excitation level ( $B$  or  $H$ ) and the excursion range ( $\Delta B$  or  $\Delta H$ ) are specified.

**phase analysis**—an analytical technique that discriminates between variables in a part undergoing electromagnetic testing part by the different phase angle changes that these conditions produce in the test signal. See also **phase detection**.

**phase angle**—the angular equivalent of the time displacement between corresponding points on two sine waves of the same frequency.

**phase detection**—the derivation of a signal whose amplitude is a function of the phase angle between two alternating currents, one of which is used as a reference.

**phase-sensitive system**—a system whose output signal is dependent on the phase relationship between the voltage returned from a pickup or sensing coil and a reference voltage.

**phase shift**—a change in the phase relationship between two alternating quantities of the same frequency.

**probe coil**—in electromagnetic testing, a small coil or coil assembly that is placed on or near the surface of test objects.

**probe coil clearance**—the perpendicular distance between adjacent surfaces of the probe and test part; also lift-off.

**recovery time**—the time required for a test system to return to its original state after it has received a signal.

**reference coil**—a coil or probe, which may be used in conjunction with the appropriate material, to electrically balance a comparative system.

**reference standard**—a tube, plate or part with artificial discontinuities used for establishing the test sensitivity setting and for periodically checking and adjusting sensitivity setting as required. (See also **standard (1)**). (E 215)

**rejection level**—the value established for a test signal above or below which test specimens are rejectable, or otherwise distinguished from the remaining specimens.

**selectivity**—the characteristic of a test system that is a measure of the extent to which an instrument is capable of differentiating between the desired signal and disturbances of other frequencies or phases.

**sensitivity control**—the control in the instrument that adjusts the amplifier gain, and is one of the factors that determines

the capacity to detect discontinuities. (E 215)

*signal gradient*—same as **differential readout**.

**signal-to-noise ratio**—the ratio of values to signal (response containing relevant information) to that of noise (response containing nonrelevant information).

*skin depth*—see **depth of penetration**.

**skin effect**—the phenomenon wherein the depth of penetration of electric currents into a conductor decreases as the frequency of the current is increased. At very high frequencies, the current flow is restricted to an extremely thin outer layer of the conductor. (See also **depth of penetration**.)

**speed effect**—the phenomenon in electromagnetic testing of which the evidence is a change in the signal voltage resulting from a change in the relative motion between the specimen and a test coil assembly.

**standard**—(1) a physical reference used as a basis for comparison or calibration; (2) a concept that has been established by authority, custom, or agreement to serve as a model or rule in the measurement of quality or the establishment of a practice or procedure.

*standard depth of penetration*—see **depth of penetration**.

**standard depth of penetration (SDP)**—the depth at which the eddy current density is reduced to approximately 37 % of the density at the surface. Eddy-current testing is most effective when the wall thickness does not exceed the SDP or in heavier tube walls when discontinuities of interest are within one SDP. (E 215)

**test coil**—the section of the coil assembly that examines the material under test in a comparative system; the coil used to examine the material in an absolute or differential comparative system (E 566).

**test frequency**—in electromagnetic testing, the number of

complete cycles per unit time of the alternating current applied to the primary test coil.

*test quality level*—see **rejection level**.

**three way sort**—an electromagnetic sort based on a signal response from the material under test above or below two levels established by three or more calibration standards.

**threshold level**—the setting of an instrument that causes it to register only those changes in response greater or less than a specified magnitude.

**threshold setting**—the setting of the instrument that causes it to register only those changes in eddy-current response greater than a specified magnitude. (E 215)

NOTE 5—Sensitivity and threshold settings usually are indicated by arbitrary numbers on the control panel of the testing instrument. These numerical settings differ among instruments of different types. It is, therefore, not proper to translate a numerical setting on one instrument to that of another type. Even among instruments of the same design and from the same manufacturer, sensitivity and threshold settings may vary slightly when detecting the same discontinuity. Therefore, undue emphasis on the numerical value of sensitivity and threshold settings is not justified. (E 215)

**transducer**—an electromagnetic device for converting electrical energy into magnetic or mechanical energy and vice versa. (E 1033)

**two-way sort**—an electromagnetic sort based on a signal response from the material under test above or below a level established by two or more calibration standards.

**wobble**—in electromagnetic testing, an effect that produces variations in coil spacing (operational lift-off) due to lateral motion of the test specimen in passing through an encircling coil.

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**Section D: Gamma- and X-Radiology**

The terms defined in Section D are the direct responsibility of Subcommittee E07.01 on Radiographic Method Radiology (X and Gamma) Method. Additional radiological terms are found in Section H.

**absorbed dose**—the amount of energy imparted by ionizing radiation per unit mass of irradiated matter. Denoted by “rad;” 1 rad = 0.01 j/kg. SI unit is “gray;” 1 gray = 1 j/kg.

**absorbed dose rate**—the absorbed dose per unit of time; rads/s. SI unit, grays/s.

**absorption**—the process whereby the incident particles or photons of radiation are reduced in number or energy as they pass through matter.

**accelerating potential**—the difference in electric potential between the cathode and anode in an X-ray tube through which a charged particle is accelerated; usually expressed in units of kV or MV.

**activation**—in neutron radiography, the process of causing a substance to become artificially radioactive by subjecting it to bombardment by neutrons or other particles.

**acute radiation syndrome**—the immediate effects of a short term, whole body overexposure of a person to ionizing radiation. These effects include nausea and vomiting, malaise, increased temperature, and blood changes.

**alphanumeric**—term pertaining to both numbers and alpha-

betical characters, typically used to designate a device capable of handling both types of characters.

**alpha particle**—a positively charged particle emitted by certain radio-nuclides. It consists of two protons and two neutrons, and is identical to the nucleus of a helium atom.

**amorphous selenium (a-Se) radiation detector array**—an array employing a biased amorphous selenium photoconductor that directly converts incident radiation into electrical charge which can then be read to form a digital image.

**analog image**—an image produced by a continuously variable physical process (for example, exposure of film).

**analog to digital converter (a/d)**—a device that changes an analog signal to a digital representation of the signal.

**anode**—the positive electrode of a discharge tube. In an X-ray tube, the anode carries the target.

**anode current**—the electrons passing from the cathode to the anode in an X-ray tube, minus the small loss incurred by the back scattered fraction.

**aperture**—an opening in material, space, or time over which

an element is considered to be active.

**area of interest**—the specific portion of the object image on the radiograph that is to be evaluated.

**array processor**—a special purpose logical processing device that performs extremely fast mathematical operation on digital arrays.

**artifact**—spurious indication on a radiograph arising from, but not limited to, faulty manufacture, storage, handling, exposure, or processing.

**autoradiograph**—the image of an object containing a radioelement obtained, on a recording medium, by means of its own radiation.

**back scattered radiation**—radiation which is scattered more than 90° with respect to the incident beam, that is, backward in the general direction of the radiation source.

**betatron**—an electron accelerator in which acceleration is provided by a special magnetic field constraining the electrons to a circular orbit. This type of equipment usually operates at energies between 10 and 31 MEV.

**blocking or masking**—surrounding specimens or covering their sections with absorptive material.

**blooming**—in radiologic real-time imaging, an undesirable condition exhibited by some image conversion devices and television pickup tubes brought about by exceeding the allowable input brightness for the device, causing the image to go into saturation, producing a fuzzy image of degraded spatial resolution and grey scale rendition.

**blow back**—the enlargement of a minified radiograph to its original size by use of an optical direct reader.

**cassette**—a light-tight container for holding radiographic recording media during exposure, for example, film, with or without intensifying or conversion screens.

**characteristic curve**—the plot of density versus log of exposure or of relative exposure. (Also called the D-log E curve or the *H* and *D* curve.)

**cine-radiography**—the production of a series of radiographs that can be viewed rapidly in sequence, thus creating an illusion of continuity.

**collimator**—a device of radiation absorbent material intended for defining the direction and angular divergence of the radiation beam.

**composite viewing**—the viewing of two or more superimposed radiographs from a multiple film exposure.

**compton scatter radiation**—the scattered X-ray or gamma ray which results from the inelastic scattering of an incident X-ray or gamma ray on an electron. Since the ejected electron has short range in most materials, it is not considered part of the scattered radiation.

**computed radiology (photo stimulated luminescence method)**—a two-step radiological imaging process; first, a storage phosphor imaging plate is exposed to penetrating radiation; second, the luminescence from the plate's photo-stimulable luminescent phosphor is detected, digitized, and presented via hard copy or a CRT.

**contrast sensitivity**—a measure of the minimum percentage change in an object which produces a perceptible density/brightness change in the radiological image.

**contrast stretch**—a function that operates on the greyscale

values in an image to increase or decrease image contrast.

**definition, image definition**—the sharpness of delineation of image details in a radiograph. Generally used qualitatively.

**densitometer**—a device for measuring the optical density of radiograph film.

**density (film)**—the quantitative measure of film blackening when light is transmitted or reflected.

$$D = \log (I_0/I) \text{ or } D = \log (I_0/R) \quad (2)$$

where:

*D* = density,  
*I*<sub>0</sub> = light intensity incident on the film,  
*I* = light intensity transmitted, and  
*R* = light intensity reflected.

**density comparison strip**—alternative term for **step-wedge comparison film**.

**digital**—the representation of data or physical quantities in the form of discrete codes, such as numerical characters, rather than a continuous stream.

**digital image**—an image composed of discrete pixels each of which is characterized by a digitally represented luminance level.

**digital image acquisition system**—a system of electronic components which, by either directly detecting radiation or converting analog radiation detection information, creates an image of the spatial radiation intensity map comprised of an array of discrete digital intensity values (see **pixel**).

**digital image enhancement**—any operation used for the purpose of enhancing some aspect of the original image.

**digital image processing system**—a system which uses algorithms to process digital image data.

**digitize (for radiology)**—the act of converting an analog image or signal to a digital presentation.

**dynamic range (for radiology)**—the span of signal intensity which defines the system's range of performance.

**equivalent I.Q.I. sensitivity**—that thickness of I.Q.I. expressed as a percentage of the section thickness radiologically examined in which a 2T hole or 2 % wire size equivalent would be visible under the same radiological conditions.

**equivalent penetrometer sensitivity**—that thickness of penetrometer, expressed as a percentage of the section thickness radiographed, in which a 2T hole would be visible under the same radiographic conditions.

**erasable optical medium**—an erasable and rewritable storage medium where the digital data is represented by the degree of reflectivity of the medium recording layer; the data can be altered.

**exposure, radiographic exposure**—the subjection of a recording medium to radiation for the purpose of producing a latent image. Radiographic exposure is commonly expressed in terms of milliamperere-seconds or millicurie-hours for a known source-to-film distance.

**exposure table**—a summary of values of radiographic exposures suitable for the different thicknesses of a specified material.

**film contrast**—a qualitative expression of the slope or steepness of the characteristic curve of a film; that property of a photographic material which is related to the magnitude of