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C H A P T E R

## **Electromagnetic Testing Glossary**

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## Introduction

Most of the definitions in this glossary are adapted from the second edition of the *Nondestructive Testing Handbook*.<sup>1-10</sup> The definitions in this glossary have been modified to satisfy peer review and editorial style. For these reasons, references in this glossary should be considered not attributions but rather acknowledgments and suggestions for further reading.

The definitions in this *Nondestructive Testing Handbook* volume should not be referenced for tests performed according to standards or specifications or in fulfillment of contracts. Standards writing bodies take great pains to ensure that their standards are definitive in wording and technical accuracy. People working to written contracts or procedures should consult definitions referenced in standards when appropriate.

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

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## Terms

### A

**absolute coil:** Coil that responds to the electromagnetic properties of that region of the test part within the magnetic field of the coil, without comparison to the response of a second coil at a different location on the same or similar material.<sup>4</sup>

**absolute measurement:** (1) Measurement made with an absolute coil.<sup>4</sup>  
(2) Measurement of a property without reference to another measurement of that property.

**acceptance criterion:** Benchmark against which test results are to be compared for purposes of establishing the functional acceptability of a part or system being examined.

**acceptance level:** Measured value or values above or below which test specimens are acceptable in contrast to *rejection level*.<sup>4,11</sup>

**acceptance limit:** Test signal value used in electromagnetic testing, establishing the group to which a material under test belongs.<sup>4,11</sup>

**acceptance standard:** Specimen, similar to the product to be tested, containing natural or artificial discontinuities that are well defined and similar in size or extent to the maximum acceptable in the product.<sup>4</sup> Acceptance standards are available also for material properties such as conductivity and hardness.

**algorithm:** Set of well defined rules or processes that prescribe the solution of a problem in a finite number of steps.<sup>4,12</sup>

**alternating current:** Electrical current that reverses its direction at regular intervals.<sup>6,10</sup>

**alternating current field:** Varying magnetic field produced around a conductor by alternating current flowing in the conductor.<sup>6,10</sup>

**alternating current magnetization:** Magnetization by a magnetic field generated when alternating current is flowing.<sup>6,10,13</sup>

**ampere (A):** SI unit of electric current.<sup>6,10</sup>

**ampere per meter (A·m<sup>-1</sup>):** SI compound unit for magnetic field intensity. The measurement 1 A·m<sup>-1</sup>, for example, describes a current of 1 A flowing through a coil of 1 m diameter.<sup>6,10,13</sup>

**amplitude response:** Property of a test system whereby the amplitude of the detected signal is measured without regard to phase. See also *phase analysis*.<sup>4,11</sup>

**analog-to-digital converter:** Circuit whose input is information in analog form and whose output is essentially the same information in digital form.<sup>4,12</sup>

**annular coil:** See *encircling coil*.

**annular coil clearance:** Mean radial distance between the inner diameter of an encircling coil assembly and test object surface in electromagnetic testing. See *fill factor*.<sup>4,10,11</sup>

**anomaly:** Variation from normal material or product quality.<sup>4</sup>

**argand diagram:** Graphical representation of a vector quantity on the *complex plane*.

**artifact:** In nondestructive testing, an indication that may be interpreted erroneously as a discontinuity.<sup>10,15</sup>

**artificial discontinuity:** See *discontinuity, artificial*.

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

**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 or as a scalar ratio of the input magnitude to the output magnitude.<sup>4,12</sup>

**automated system:** Acting mechanism that performs required tasks at a determined time and in a fixed sequence in response to certain conditions.<sup>10</sup>

## B

**band pass filter:** Frequency filter that has a single transmission band between two cutoff frequencies, neither of the cutoff frequencies being zero or infinity.<sup>4,10,12</sup>

**bandwidth:** Difference between the cutoff frequencies of a bandpass filter.<sup>14</sup>

**blister:** Discontinuity in metal, on or near the surface, resulting from the expansion of gas in a subsurface zone. Very small blisters are called *pinheads* or *pepper blisters*.<sup>10</sup>

**blowhole:** Hole in a casting or a weld caused by gas entrapped during solidification.<sup>10</sup>

**bobbin coil:** Cylindrically wound coil.

**brittleness:** Characteristic of a material that leads to crack propagation without appreciable plastic deformation.<sup>10</sup>

**bucking coil:** See *differential coils*.

## C

**calibration, instrument:** Adjustment of instrument readings to known reference standard.

**casing:** Many strings of pipe that are used to line the hole during and after drilling of a water, gas or oil well.<sup>10</sup>

**casing string:** Tubular structure on the outer perimeter of a water, gas or oil well hole. The casing string is a permanent part of the well and many casing strings are cemented into the formation.<sup>10</sup>

**central conductor:** Electric conductor passed through the opening in a part with an aperture, or through a hole in a test object, for the purpose of creating a circular magnetic field in the object.<sup>10</sup>

**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*.

**circular magnetization:** Magnetization in an object resulting from current passed longitudinally through the object itself or through an inserted central conductor.<sup>10,15</sup>

**circumferential coil:** See *encircling coil*.

**coil:** One or more loops of a conducting material; a single coil may be an exciter and induce currents in the material or it may be a detector or both simultaneously.<sup>4</sup>

**coil clearance:** See *liftoff*.

**coil spacing:** In electromagnetic testing, the axial distance between two encircling or inside coils of a differential or remote field test system.<sup>4,11</sup>

**comparative measurement:** In electromagnetic testing, a measurement based on the imbalance in a system and using comparator coils in contrast to differential and absolute measurements. See also *comparator coils*.<sup>4,11</sup>

**comparator coils:** In electromagnetic testing, two or more coils electrically connected in series opposition and arranged so that there is no mutual induction (coupling) between them. Any electromagnetic condition that is not common to the test specimen and the standard will produce an imbalance in the system and thereby yield an indication. See also *differential coils*.<sup>4,11</sup>

**complex plane:** Plane defined by two perpendicular reference axes, used for plotting a complex variable (such as impedance) or functions of this variable (such as a transfer function).<sup>4,12</sup>

**complex plane diagram:** Graphical presentation of complex quantities where the real and imaginary components are represented along the horizontal and vertical axes, respectively.<sup>4</sup> Types of complex plane diagram include *impedance plane diagram*, voltage plane diagram and phase amplitude diagram.

**conductance (G):** Transmission of electric current through material. Measured in siemens (S). Inversely related to *resistance R* (ohm).

$$G = \frac{1}{R}$$

**conductivity (σ):** Ability of material to transmit electric current. Measured in siemens per meter. Inversely related to *resistivity ρ*.

$$\sigma = \frac{1}{\rho}$$

**contact head:** Electrode assembly used to clamp and support an object to facilitate passage of electric current through the object for circular magnetization.<sup>10,15</sup>

**coupled:** (1) Of two electric circuits, having an impedance in common so that a current in one causes a voltage in the other.<sup>10,11</sup> (2) Of two coils, sharing parts of their magnetic flux paths.

**coupling:** Percentage of magnetic flux from a primary circuit that links a secondary circuit; effectiveness of a coil in inducing eddy currents in the test object.<sup>4</sup>

**coupling coefficient:** Fraction of magnetic flux from one circuit (test coil) that threads a second circuit (test object); the ratio of impedance of the coupling to the square root of the product of the total impedances of similar elements in the two meshes.<sup>4,12</sup>

**crack:** (1) Break, fissure or rupture, sometimes V shaped 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 in a casting after solidification, because of excessive stress generally resulting from nonuniform cooling.<sup>10</sup>

**crack, cooling:** Crack in bars of alloy or tool steels 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 crack that develops on the surface and is caused by the repeated loading and unloading of the object.<sup>10</sup>

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

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

**crack, longitudinal:** Crack parallel to the length of the test object.<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 occurs in adjacent portions.<sup>10</sup>

**crack, transverse:** Crack at right angle to the length of the test object.<sup>10</sup>

**current flow technique:** Magnetizing by passing current through an object using prods or contact heads. The current may be alternating current or rectified alternating current.<sup>10,15</sup>

**current induction technique:** Magnetization in which a circulating current is induced in a ring component by a fluctuating magnetic field.<sup>10,15</sup>

**cycle:** Single period of a waveform or other variable. See *period*.

## D

**defect:** Discontinuity whose size, shape, orientation or location make it detrimental to the useful service of its host object or which exceeds the accept/reject criteria of an applicable specification.<sup>10,16</sup> Note that some discontinuities may not exceed specifications and are therefore not defects. Compare *discontinuity* and *indication*.<sup>10</sup>

**demodulation:** Process wherein a carrier frequency modulated with a signal of lower frequency than the carrier frequency is converted to a close representation of the original modulating signal.<sup>14</sup> See *modulation*.

**depth of penetration:** See *skin effect* and *standard depth of penetration*.

**detector coil:** See *sensing coil*.

**differential amplifier:** Amplifier whose output signal is proportional to the algebraic difference between two input signals.<sup>4,12</sup>

**differential coils:** Two or more physically adjacent and mutually coupled coils connected in series opposition such that an imbalance between them, causing a signal, will be produced only when the electromagnetic conditions are different in the regions beneath two of the coils. In contrast, *comparator coils* are not adjacent or mutually coupled.

**differential measurement:** In electromagnetic testing, the measurement of system imbalance by using differential coils, in contrast to absolute and comparative measurements.<sup>4,11</sup>

**differentiated signal:** In electromagnetic testing, an output signal proportional to the input signal's rate of change.<sup>4,11</sup>

**direct current:** Electric current flowing continually in one direction without variation in amplitude through a conductor.<sup>10,16</sup> See also *full-wave rectified direct current* and *half-wave direct current*.

**direct current field:** Active magnetic field produced by direct current flowing in a conductor or coil.<sup>10,16</sup>

**discontinuity:** Interruption in the physical structure or configuration of a test object.<sup>10,17</sup> After nondestructive testing, unintentional discontinuities interpreted as detrimental to the serviceability of the host object may be called *flaws* or *defects*.<sup>10</sup> Compare *defect* and *indication*.

**discontinuity, artificial:** Reference discontinuity such as hole, indentation, crack, groove or notch introduced into a reference standard to provide accurately reproducible indications for determining sensitivity levels.<sup>10</sup>

**discontinuity inversion:** Technique for measuring some dimension(s) of a discontinuity by the application of a mathematical algorithm to the measured test data.<sup>4</sup>

**discontinuity resolution:** Property of a test system that enables the separation of indications due to discontinuities near each other in a test specimen.<sup>4,11</sup>

## E

**eddy current:** Electrical current induced in a conductor by a time varying magnetic field.<sup>4</sup>

**eddy current testing:** Nondestructive test technique 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, hall effect device or other magnetic flux sensor for subsequent analysis by suitable instrumentation and techniques.<sup>4,11</sup>

**edge effect:** In electromagnetic testing, the disturbance of the magnetic field and eddy currents because of the proximity of an abrupt change in geometry, such as an edge of the test object. Sometimes called *end effect*. The effect generally results in the masking of discontinuities within the affected region.<sup>4,11</sup>

**effective depth of penetration:** In electromagnetic testing, the minimum depth beyond which a test system can no longer practically detect a further increase in specimen thickness.

**electric field:** Vector field of either the electric field intensity (volt per meter) or of the electric flux density (coulomb per meter squared).

**electrical center:** 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.<sup>4,11</sup>

**electrode:** Conductor by which a current passes into or out of a test object.<sup>10,13</sup>

**electromagnet:** Ferromagnetic core surrounded by a coil of wire that temporarily becomes a magnet when an electric current flows through the wire.<sup>10,15</sup>

**electromagnetic acoustic transducer (EMAT):** Electromagnetic device using Lorentz forces and magnetostriction in conductive and ferromagnetic materials to generate and receive acoustic signals for ultrasonic nondestructive tests.<sup>10</sup>

**electromagnetic testing (ET):** Nondestructive test method for materials, including magnetic materials, that uses electromagnetic energy, either alternating or direct current, to yield information regarding the quality and characteristics of the tested material.<sup>10,11</sup>

**EMAT:** *Electromagnetic acoustic transducer.*

**encircling coil:** In electromagnetic testing, a coil or coil assembly that surrounds the test object. Such a coil is also called an *annular coil*, *circumferential coil* or *feed-through coil*.<sup>10,11</sup>

**end effect:** In bar and tube testing, *edge effect*.

**ET:** Electromagnetic testing.

**evaluation:** Review following interpretation of indications, to determine whether they meet specified acceptance criteria.

**excitation coil:** Coil that carries the excitation current. Also called *primary coil* or *winding*. See *sensing coil*.<sup>10</sup>

**external discontinuities:** Discontinuities on the outside or exposed surface of a test object.<sup>10</sup>

## F

**false indication:** Test indication that could be interpreted as originating from a discontinuity but which actually originates where no discontinuity exists in the test object. Distinct from nonrelevant indication. Compare *defect*.<sup>10</sup>

**feed-through coil:** See *encircling coil*.

**ferrite:** Any of several magnetic substances that consist essentially of an iron oxide combined with one or more metals (such as manganese, nickel or zinc) having high magnetic permeability and high electrical resistivity.<sup>6</sup>

**ferromagnetic material:** Material such as iron, nickel or cobalt whose relative permeability is considerably greater than unity and depends on the magnetizing force and often exhibits hysteresis.<sup>10,12</sup> Materials that are most strongly affected by magnetism are called *ferromagnetic*.<sup>10</sup>

**fill factor:** For encircling coil electromagnetic testing, the ratio of the cross sectional area of the test object to the effective cross sectional core area of the primary encircling coil (outside diameter of coil form, not inside diameter that is adjacent to the object).<sup>10,11,13</sup> 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.<sup>10,11</sup>

**fill factor effect:** Effect of fill factor on coupling between coil and test object. See *coupling coefficient*.<sup>4</sup>

**filter:** Network that leaves a signal unaffected over a prescribed range of frequencies and attenuates signal components at all other frequencies.<sup>4,11</sup>

**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>4</sup>

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

**flaw inversion:** See *discontinuity inversion*.

**flux density:** See *magnetic flux density*.

**flux leakage:** See *magnetic flux leakage field*; *magnetic flux leakage technique*; *magnetic flux meter*.

**flux meter:** See *magnetic flux meter*.

**full-wave rectified direct current:** Single-phase or three-phase alternating current rectified to produce unidirectional current. The rectified current contains ripple.

## G

**gauss (G):** Obsolete unit of magnetic flux density, replaced in SI by *tesla* (T).  
 $1 \text{ G} = 0.1 \text{ mT}$ .<sup>10</sup>

**gauss meter:** Gage that measures magnetic flux density in gauss (or tesla).<sup>10</sup>

**general examination:** In personnel qualification, test or examination of a person's knowledge, typically (in the case of nondestructive testing personnel qualification) a written test on the basic principles of a nondestructive testing method and general knowledge of basic equipment used in the 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 excessive grinding heat or the high sensitivity of the material. Grinding cracks typically are 90 degrees to the direction of grinding.<sup>10</sup>

## H

**half-wave direct current:** Single-phase alternating current half-wave rectified to produce a pulsating unidirectional current. Also called *half-wave current*.<sup>10,15</sup>

**hall detector:** Semiconductor element that produces an output electromotive force proportional to the product of the magnetic field intensity and a biasing current.<sup>10</sup>

**hall effect:** Potential difference developed across a conductor at right angles to the direction of both the magnetic field and the electric current. Produced when a current flows along a rectangular conductor subjected to a transverse magnetic field.<sup>10,13</sup>

**hardness:** Resistance of metal to plastic deformation, usually by indentation. However, the term may also refer to stiffness or temper or to resistance to scratching, abrasion or cutting.<sup>10</sup>

**heat affected zone (HAZ):** 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:** Measurement unit of frequency, equivalent to one cycle per second.<sup>10,12</sup>

**horseshoe coil:** Probe coil in which the ferrite core of the coil is horseshoe shaped. Also called a *U shaped coil*.<sup>4</sup>

**hysteresis:** Apparent lagging of the magnetic effect when the magnetizing force acting on a ferromagnetic body is changed; phenomenon exhibited by a magnetic system wherein its state is influenced by its previous history.<sup>10</sup>

**hysteresis loop:** Curve showing flux density  $B$  plotted as a function of magnetizing force  $H$  as magnetizing force is increased to the saturation point in both negative and positive directions sequentially. The curve forms a characteristic shaped loop.

## I

**IACS:** *International Annealed Copper Standard*.

**impedance:** Opposition that a circuit presents to the flow of an alternating current, specifically the complex quotient of voltage divided by current.<sup>10,11</sup>

**impedance analysis:** In electromagnetic testing, an analytical technique that consists of correlating changes in the amplitude, phase, quadrature components or all of these of a complex test signal voltage to the condition of the test specimen.<sup>10,11</sup>

**impedance plane diagram:** Graphical representation of the locus of points indicating the variations in the impedance of a test coil as a function of a parameter, such as *conductivity* or *lift-off*.

**incremental permeability:** Ratio of the change in magnetic induction to the corresponding change in magnetizing force.

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

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

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

**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).<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.<sup>10,17</sup>

**induced current technique:** See *current induction technique*.

**inductor:** Device consisting of one or more associated windings, with or without a magnetic core, which impedes the flow of current.

**initial permeability:** Slope of the induction curve at zero magnetizing force as the test specimen begins to be magnetized from a demagnetized condition (slope at the origin of the *B,H* curve before hysteresis is observed).

**inserted coil:** See *inside diameter coil*.

**inside coil:** See *inside diameter coil*.

**inside diameter coil:** Coil or coil assembly used for electromagnetic testing by insertion into the test piece, as with an inside probe for tubing. Also called *inserted coil*.<sup>4,11</sup>

**intergranular stress corrosion cracking (IGSCC):** Anomaly caused by intergranular corrosion as a result of sensitized material, stress and corrosive environment (typical in the heat affected zone of stainless steel welds).

**International Annealed Copper Standard (IACS):** Conductivity measurement system in which the conductivity of annealed, unalloyed copper is arbitrarily rated at 100 percent and in which the conductivities of other materials are expressed as percentages of this standard. See also *conductivity* and *percent International Annealed Copper Standard*.

**interpretation:** Determination of the significance of test indications from the standpoint of their relevance or irrelevance, that is, from the standpoint of whether they are detrimental or inconsequential.<sup>10</sup>

**inversion, discontinuity:** See *discontinuity inversion*.

## L

**leakage flux:** (1) Magnetic flux of the coil that does not link with the test object. (2) Magnetic flux that leaves a saturated or nearly saturated specimen at a discontinuity.<sup>4</sup>

**level, acceptance:** See *acceptance level*.

**level, rejection:** See *rejection level*.

**liftoff:** Distance between the probe coil and the test object.<sup>4</sup>

**liftoff effect:** In an electromagnetic test system output, the effect observed due to a change in coupling between a test object and a probe whenever the distance between them is varied.<sup>10,11</sup>

**longitudinal magnetic field:** Magnetic field wherein the flux lines traverse the component in a direction essentially parallel with its longitudinal axis.<sup>10,15</sup>

## M

**magnetic circuit:** Closed path that allows magnetic flux to flow.

**magnetic field:** Distribution of a vector quantity that is a measure of an exerted magnetic force.

**magnetic field indicator:** Device used to locate or determine relative intensity of a flux leakage field.<sup>10,15</sup>

**magnetic field intensity:** Strength of a magnetic field at a specific point. Measured in ampere per meter.<sup>10</sup>

**magnetic flux density:** Normal magnetic flux per unit area, measured in *tesla* (T).<sup>10,13</sup>

**magnetic flux leakage field:** Magnetic field that leaves or enters the surface of an object.<sup>10,15</sup>

**magnetic flux leakage technique:** Electromagnetic test technique for the detection and analysis of a surface discontinuity or near surface discontinuity using the flux that leaves a magnetically saturated, or nearly saturated, test object at a discontinuity.<sup>10</sup>

**magnetic flux meter:** Electronic device for measuring magnetic flux leakage.<sup>10</sup>

**magnetic flux leakage:** Excursion of magnetic lines of force from the surface of a test specimen.<sup>4,11</sup>

**magnetic particle testing (MT):** Nondestructive test method using magnetic leakage fields and indication materials to disclose surface and near surface discontinuities.<sup>10,15</sup>

**magnetic saturation:** That degree of magnetization where a further increase in magnetizing force produces no significant increase in magnetic flux density in an object.<sup>10,11</sup>

**magnetometer:** Device for measuring the strength of magnets or the intensity of magnetic fields.<sup>10,16</sup>

**magnitude:** Absolute value of a complex quantity (number) without reference to the phase of the quantity.<sup>4</sup>

**Maxwell's equations:** Fundamental equations of electromagnetic field theory:

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \cdot \mathbf{D} = \rho$$

where  $\mathbf{B}$  = magnetic flux density,  $\mathbf{D}$  = electric flux density,  $\mathbf{E}$  = electric field intensity,  $\mathbf{H}$  = magnetic field strength,  $\mathbf{J}$  = current density and  $\rho$  = volume charge density.<sup>4</sup>

**microwave testing:** Nondestructive testing method that uses, for its probing energy, electromagnetic radiation at radio frequencies — from 0.3 to 300 GHz, with wavelengths from 1 mm to 1 m.<sup>10</sup>

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

**modulation:** Process of imparting information to a carrier signal by the introduction of amplitude or phase perturbation.<sup>14</sup>

**MT:** Magnetic particle testing.

**multifrequency:** Two or more frequencies applied sequentially or simultaneously to the test coil.

**multifrequency technique:** Use of the response of a test specimen to more than one frequency, usually to separate effects that would be indistinguishable at a single frequency.<sup>4</sup>

**multiparameter:** Of or pertaining to a test system having many parameters that affect the response. These parameters can often be distinguished with a multifrequency technique.<sup>4</sup>

**multivariable:** See *multiparameter*.<sup>4</sup>

**mutual inductance:** Property of two electrical circuits whereby a voltage is induced in one circuit by a change of current in the other circuit.<sup>4,12</sup>

## N

**NDC:** *Nondestructive characterization*.

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

**NDI:** *Nondestructive inspection*.

**NDT:** *Nondestructive testing*.

**noise:** In electromagnetic testing, any nonrelevant signal that tends to interfere with the normal reception or processing of a desired discontinuity signal. Such noise signals may be due to an extraneous source or generated by heterogeneities in the test part that are not detrimental to the use of the part.<sup>4,11</sup>

**nondestructive characterization (NDC):**

Branch of nondestructive testing concerned with the description and prediction of material properties and behaviors 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, *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>

**nonferromagnetic material:** Material not magnetizable and essentially not affected by magnetic fields.<sup>4,11</sup>

**normalized impedance diagram:**

Diagram in which the impedance of the probe in air is a reference value to which impedance values in other conditions are compared. Usually the plotted data are (1) the measured reactance divided by the reactance of the coil in air versus (2) the measured resistance less the resistance in air divided by the coil reactance in air.

**null:** To adjust a bridge circuit so that the test sample and reference arms produce equal and opposite currents through the detector.<sup>4</sup>

**null signal:** Fixed component of the test coil signal that is subtracted from the output signal leaving only that part of the signal that varies with test object conditions; it reduces dynamic range requirements.<sup>4</sup>

**numerical analysis:** Technique to generate numbers as the solution to a mathematical model of a physical system; used in place of a closed form analytic expression; usually requires digital computation.<sup>4</sup>

**O**

**OCTG:** Oil country tubular goods.<sup>10</sup>

**oersted (Oe):** Obsolete measurement unit of magnetic field intensity, replaced in SI by ampere per meter ( $A \cdot m^{-1}$ ).  
 $1 \text{ Oe} = 79.57747 \text{ A} \cdot m^{-1}$ .

**ohm ( $\Omega$ ):** Measurement unit of electrical resistance.

**oil country tubular goods:** Hollow cylindrical components used to convey petroleum and related products.<sup>10</sup>

**optimum frequency:** In electromagnetic testing, that frequency that provides the largest signal-to-noise ratio obtainable for the detection of an individual material property.

**P**

**pancake coil:** Probe coil whose axis is normal to the surface of the test material and whose length is not larger than the radius.<sup>4</sup>

**paramagnetic material:** In electromagnetic testing, a material that has a relative permeability slightly greater than unity and is practically independent of the magnetizing force.<sup>10,11</sup>

**percent International Annealed Copper Standard (%IACS):** Measurement of conductivity as a percentage of the conductivity of pure copper, arbitrarily rated at 100 percent. See also *International Annealed Copper Standard*.

**period:** Absolute value of the minimum interval after which the same characteristics of a periodic waveform or a periodic feature repeat.<sup>4</sup>

**permeability:** Ratio of magnetic induction to magnetizing force. This relationship is either (1) absolute permeability, in general the quotient of magnetic induction divided by the magnetizing force, or (2) *relative permeability* (or specific permeability), a pure number that is the same in all unit systems. The value and dimension of absolute permeability depend on the system of units used. In anisotropic media, permeability is a matrix.<sup>4,12</sup>

**phase analysis:** Analytical technique that discriminates between variables in a part undergoing electromagnetic testing by the different phase angle and amplitude changes that these conditions produce in the test signal. See also *phase detection*.<sup>4,11</sup>

**phase angle:** Angular equivalent of the time displacement between corresponding points on two sine waves of the same frequency.<sup>4,11</sup>

**phase detection:** 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.<sup>4,11</sup>

**phase sensitive system:** System whose output signal depends on the phase relationship between the voltage returned from a pickup or sensing coil and a reference voltage.<sup>4,11</sup>

**phase shift:** Change in the phase relationship between two alternating quantities of the same frequency.<sup>4,11</sup>

**phasor:** Complex number that represents the amplitude and phase of a quantity that varies sinusoidally with time. A phasor is not a vector, because the orientation of a vector represents direction.

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

**probe coil clearance:** Perpendicular distance between adjacent surfaces of the probe and test part. See *lift-off*.<sup>4,11</sup>

**pulse technique:** Multifrequency technique in which a broadband excitation such as an impulse is used. Either the frequency components are extracted and analyzed or the interpretation is based directly on characteristics of the time domain waveform.<sup>4</sup>

## Q

**Q of a coil:** *Quality factor* of a coil; related to the ratio of maximum energy stored to the total energy lost per period.

**quadrature:** Relation between two periodic functions when the phase difference between them is one fourth of a period.<sup>4,12</sup>

**qualification:** Process of demonstrating that an individual has the required amount and the required type of training, experience, knowledge and capabilities.<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 the quality assurance program. Quality control may include nondestructive testing in the manufacturing cycle.<sup>10</sup>

**quality factor:** Of a coil, the ratio of reactance to resistance defined at the operating frequency.

## 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 nondestructive testing personnel qualification and certification program.<sup>10</sup>

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

**reference coil:** In electromagnetic testing, the section of the coil assembly that excites or detects the electromagnetic field in the reference standard of a comparative system.<sup>4,11</sup>

**reference number:** Number associated with the impedance of a coil adjacent to a test sample.

**reference standard:** Reference used as a basis for comparison or calibration. In tube testing, a tube with artificial discontinuities used for establishing the test sensitivity setting and for periodically checking and adjusting the sensitivity setting as required. See also *acceptance standard*.<sup>4,11</sup>

**reflection probe:** Coil system that uses both an excitation and a detection or sensing coil on the same side of the sample.<sup>4,11</sup>

**rejection level:** Value established for a test signal above or below which test specimens are rejectable or otherwise distinguished from the remaining specimens. This level is different from the *rejection level* as defined for ultrasonic and other test systems.<sup>4,11,20</sup>

**relative permeability:** Ratio of the permeability of the material to the permeability of vacuum. See also *permeability*.<sup>4</sup>

**resistance, electrical (R):** Opposition to transmission of electric current through material; ratio of voltage to current. Measured in ohm ( $\Omega$ ). Inversely related to *conductance*:

$$R = \frac{1}{G} = \frac{\rho L}{A}$$

where  $A$  is the conductor's cross sectional area (square meter),  $G$  is conductance (siemens),  $L$  is the length of the conductor (meter) and  $\rho$  is resistivity (ohm meter).

**resistivity ( $\rho$ ):** Ability of material to resist electric current. Measured in ohm meter ( $\Omega\cdot\text{m}$ ), which is the resistance of a cube made of the material whose dimensions are 1 m on each side. Inversely related to *conductivity*  $\sigma$  (siemens per meter):

$$\rho = \frac{1}{\sigma}$$

**response function:** Ratio of response to excitation, both expressed as functions of the complex impedance.<sup>4,12</sup>

## S

**scalar:** Quantity completely specified by a single number and unit.<sup>4,12</sup>

**search coil:** Detection coil, usually smaller than the excitation coil.<sup>4</sup>

**secondary magnetic flux:** Magnetic flux due to induced flow of eddy currents.<sup>4</sup>

**selectivity:** Characteristic of a test system, a measure of the extent to which an instrument can differentiate between the desired signal and disturbances of other frequencies or phases.<sup>4,11</sup>

**self-inductance:** Property of an electric circuit whereby an electromotive force is induced in that circuit by a change of current in the circuit.<sup>4,12</sup>

**sensing coil:** Coil that detects changes in the flow of eddy currents induced by an excitation coil; sensing and excitation coils can be one and the same.<sup>4</sup> Also called *detector coil*.

**shielding:** Conducting or magnetic material (or a combination of both) placed so as to decrease susceptibility to interference.<sup>4</sup>

**SI (International System of Units):**

Universal, coherent system of measurement in which the following seven units are considered basic: meter, mole, kilogram, second, ampere, kelvin and candela.<sup>4,12</sup>

**siemens per meter (S·m<sup>-1</sup>):** SI unit of conductivity.

**signal:** Physical quantity, such as electrical voltage, that contains relevant information.<sup>4,11</sup>

**signal-to-noise ratio:** Ratio of signal values (responses that contain relevant information) to baseline noise values (responses that contain nonrelevant information). See *noise*.<sup>10,11</sup>

**skin depth:** *Standard depth of penetration*. See also *skin effect*.

**skin effect:** Phenomenon wherein the depth of penetration of electrical 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 *standard depth of penetration*.<sup>10,11</sup>

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

**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:** Signal aspect showing the distribution of the various frequency components of the signal.<sup>14</sup> Also called *fourier spectrum*.

**SQUID:** Superconducting quantum interference device, a sensitive detector of magnetic fields using quantum effect.<sup>4</sup>

**standard:** (1) Physical object with known material characteristics used as a basis for comparison or calibration; *reference standard*. (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. (3) Document to control and govern practices in an industry or application, applied on a national or international basis and usually produced by consensus. See also *acceptance standard* and *reference standard*.<sup>10,11,18</sup>

**standard depth of penetration:** In electromagnetic testing, the depth at which the magnetic field intensity or intensity of induced eddy currents has decreased to 37 percent of its surface value. The square of the depth of penetration is inversely proportional to the frequency of the signal, the conductivity of the material and the permeability of the material. See also *skin effect*.<sup>10,11</sup>

**standardization, instrument:** Adjustment of instrument readout before use to an arbitrary reference value.

**stationary:** Of a signal, having statistical properties such as mean and variance that do not vary with time.<sup>14</sup>

## T

**tangential magnetic field:** Magnetic field at an object's surface parallel to the surface. The tangential field is continuous (equal on either side) with the interface of material to air. Measurement can be influenced by external fields.<sup>10</sup>

**tape head probe:** Head of a tape recorder used as an eddy current coil; a type of horseshoe coil.<sup>4</sup>

**tesla (T):** SI unit of measure for magnetic flux density. 1 T = 1 Wb·m<sup>-2</sup> = 10 000 G.<sup>10</sup>

**tesla meter:** Gage that measures magnetic flux density in tesla.<sup>10</sup>

**test coil:** Section of a coil assembly that excites or detects the magnetic field in the material under electromagnetic test.<sup>4,11</sup>

**test frequency:** In electromagnetic testing, the number of complete cycles per unit time of the alternating current applied to the primary test coil.<sup>4,11</sup>

**test quality level:** See *rejection level*.

**text information:** Information stored on recording medium to support recorded eddy current data.

**three-way sort:** Electromagnetic sort based on a test object signal response above or below two levels established by three or more calibration standards.<sup>4,11</sup>

**threshold level:** Setting of an instrument that causes it to register only those changes in response greater or less than a specified magnitude.<sup>4,11</sup>

**through-transmission:** Of or pertaining to electromagnetic techniques where the excitation field penetrates the test object so that the detected signal is responsive to features external to or on the opposite surface.

**toroidal field:** Induced magnetic field occurring in a ring test object when current is induced. See *current induction technique*.<sup>10</sup>

**trace:** Line formed by an electron beam scanning from left to right on a video or computer screen to generate an image.<sup>10</sup>

**transducer:** Device by means of which energy can flow from one or more transmission systems or media to one or more other transmission systems or media; sensor or probe.

**tubing string:** Pipe with which oil or gas has contact as it is brought to the earth's surface.<sup>10</sup>

**two-way sort:** Electromagnetic sort based on a test object signal response above or below a level established by two or more calibration standards.<sup>4,11</sup>

## U

**U shaped coil:** See *horseshoe coil*.

**Unified Numbering System:**

Alphanumeric system for identifying alloys according to a registry maintained by ASTM International and SAE International.<sup>21</sup>

**unit of data storage:** Discrete physical recording medium on which text information is stored.

## V

**vector quantity:** Any physical quantity whose specification involves both magnitude and direction and that obeys the parallelogram law of addition.<sup>4,12</sup>

**volt (V):** Measurement unit of electric potential.

## W

**wobble:** In electromagnetic testing, an effect that produces variations in an output signal of a test system and arises from coil spacing (operational liftoff) variations due to lateral motion of the test specimen in passing through an encircling coil or of a bobbin coil passing through a cylindrical test object.<sup>4,11</sup>

## Y

**yoke:** Magnet that induces a magnetic field in the area of a part that lies between its poles. Yokes may be permanent magnets or either alternating current or direct current electromagnets.<sup>4,11</sup>

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