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C H A P T E R

Magnetic Testing Glossary

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PART 1. Terms

Introduction

Purpose

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. For example, persons who work in accordance with standards published by ASTM International are required to refer to definitions in the *ASTM Book of Standards*.¹

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

On References

Many definitions in this glossary are adapted from other volumes of the *Nondestructive Testing Handbook* series. Many definitions from the second edition's *Magnetic Particle Testing* (1989)² are reprinted but not referenced below. Definitions from three volumes of the third edition are referenced.³⁻⁵

Some terms apply generally to nondestructive testing and are not specific to magnetic techniques — terms on subjects such as metallurgy, quality control and personnel qualification. Most of these definitions come from the second edition volume *Nondestructive Testing Overview* (1996),⁶ and some are rephrased in the most recent volume, the third edition's *Ultrasonic Testing* (2007).⁴

All 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.

Definitions

A

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.⁴

acceptance level: Measured value or values above or below which test objects are acceptable in contrast to *rejection level*.⁴

acceptance limit: Test signal value used in electromagnetic testing, establishing the group to which a material under test belongs.⁴

acceptance standard: (1) 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.⁴ (2) Document defining acceptable discontinuity size limits.⁵ See also *standard*.

accommodation: Of the eye, adjustment of the lens' focusing power by changing the thickness and curvature of the lens through the movement of tiny muscles.³

ACGIH: American Conference of Governmental Industrial Hygienists.

agglomeration: Clustering where smaller particles collide and adhere as groups.

alternating current: Electric waveform that changes cyclically in magnitude and direction.⁷

alternating current magnetization: Inducing of a magnetic state by a cyclically reversing waveform, a state generally characterized by its form following ability and by shallow penetration.

ampere (A): SI unit of electric current.⁴

ampere per meter (A · m⁻¹): SI derived unit of magnetic field intensity. The measurement 1 A · m⁻¹, for example, describes a current of 1 A flowing through a coil of 1 m diameter.⁴

ampere turn: Unit for expressing the magnetomotive force required for magnetization using a coil in terms of the product of the number of coil turns and the current in amperes flowing through the coil.

angstrom (Å): Disused unit of length.
1 Å = 0.1 nm.

anomaly: In nondestructive testing, an unintentional or undesired material condition that may qualify as a defect. Compare *defect*; *discontinuity*. Some anomalies, such as inadequate case hardening or rough surface finish, may be defects but, because there is no interruption in the material structure, are not discontinuities.

apposing field: See *bucking field*.

arc: Current flow across a gap, producing intense heat and light.

arc strikes: Localized heat damage to an object sometimes caused by poor arc weld initiation technique or by poor coupling between a test object and contact pads or prods.

arc welding: See *electric arc welding*.

articulated pole pieces: Independently adjustable legs of an electromagnetic yoke enabling satisfactory contact on irregular test object profiles.

ASNT: American Society for Nondestructive Testing.

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

automated system: Acting mechanism that performs required tasks at a determined time and in a fixed sequence in response to certain conditions.⁴

axial: Of or pertaining to a direction along the length of an oblong object and perpendicular to its radius — for example, down the length of a cylinder. Compare *radial*; *tangential*.

B

background: (1) In magnetic particle testing, the appearance or brightness of the surrounding area acting to reduce the contrast of an indication. (2) Nonrelevant signal that tends to interfere with the normal reception or interpretation of the target being sought.

bath: Combination of well agitated water based or oil based carrier fluid with a controlled concentration of suspended magnetic particles.

bearding: See *furring*.

berthold penetrometer: Shared flux indicator of magnetic field orientation, for use during continuous magnetization. Similar to a pie gage but containing an cover plate with height adjustable to vary the magnetic flux density required to form an indication. See also *shared flux indicator*.

black light: Disfavored term for *ultraviolet radiation*. The term is misleading because the phenomenon is not black and is not light and has also been applied to the lamp.

blind spot: Portion of the retina where the optic nerve enters the eye and no photoreceptors (rods and cones) are present.

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*.⁴

blowhole: Hole in a casting or a weld caused by gas entrapped during solidification.⁴

blue light hazard: Danger posed to the eye due to long term exposure to high intensity visible light.

borescope: Industrial endoscope; electronic and/or optical device that allows the inspector to view normally inaccessible interior surfaces.

borescope, fiber optic: Industrial endoscope, or fiber optic borescope, that uses glass or quartz fibers to transmit light and the optical path to and from the test object.

bucking field: Magnetic flow technique configuration where poles of like polarity are induced on the ends of a test object to force magnetization into extremities that are normally field free.

butt weld: Weld that joins the edges of work pieces in the same plane.

C

calibration: (1) Determination of the correlation between a known input value and an output value from a measurement device. (2) Act of returning an instrument to the condition of the original equipment manufacturer.

candela (cd): Base SI unit of luminous intensity, in a given direction, of a monochromatic radiation source that has a frequency of 5.4×10^{14} Hz and that has a radiant intensity in that direction of $1.464 \text{ mW}\cdot\text{sr}^{-1}$.

capacitor discharge technique: Magnetization technique generally characterized by a short duration, high intensity electrical pulse, often performed on oil field components.

carrier fluid: Water based or oil based component of the bath, the agitation of which holds magnetic particles in suspension.

central conductor: See *internal conductor*.

centrifuge tube: Vial that holds liquids and has graduations to indicate the concentration of solids that settle out of a known suspension volume.

certification: With respect to nondestructive test personnel, the process of providing written testimony that an individual has met the requirements of a specific practice or standard. See also *certified* and *qualified*.⁵

certified: With respect to nondestructive test personnel, having written testimony of qualification. See also *certification* and *qualification*.⁵

CGS system: Obsolete measurement system based on the centimeter, gram and second. Compare *SI*.

checks: See *grinding crack*.

circular magnetic field: Active or residual magnetization oriented along the circumference. See also *circular magnetization*, *current flow technique* and *right hand rule*.

circular magnetization: Result of current flow or internal conductor techniques where flux lines are oriented along the circumference of the test object.

circumferential magnetization: See *circular magnetization*.

coercive force: Reverse external magnetic field intensity required to reduce the test object's bulk magnetism to zero.

coercivity: See *coercive force*.

code: Standard enacted or enforced as a law.³

coil technique: Magnetization technique using an encircling current carrying solenoid that imparts a longitudinal magnetic field in ferromagnetic components with a length-to-diameter ratio greater than 3. See also *L·D⁻¹ ratio* and *self-demagnetizing factor*.

coil shot: See *coil technique*. One instance of the coil technique; one pulse of current in the coil technique.

color: Visual sensation by means of which humans distinguish light of differing hue (predominant wavelengths), saturation (degree to which those radiations predominate over others) and lightness.³

color blindness: Deficiency in ability to perceive or distinguish hues.³

conditioning agent: Additive to water based carrier fluid aiding with defoaming, surface wetting, particle dispersion, pH or corrosivity, or antifungal properties.

conductance (G): Transmission of electric current through material. Measured in siemens (S). Inversely related to electrical *resistance (R)*:⁴

$$(1) \quad G = \frac{1}{R}$$

conductivity (σ): Ability of material to transmit electric current, measured in siemens per meter. Reciprocal or inverse of *resistivity ρ*:⁴

$$(2) \quad \sigma = \frac{1}{\rho}$$

cone cells: Common name for three color sensitive photoreceptors concentrated at the inner region of the retina.

Cones assist with mesopic vision and are responsible for photopic vision. Compare *rod cells*.

confidence level: Level of assurance for detecting a specified discontinuity size with a specified probability.³ See also *probability of detection*.

contact technique: See *current flow technique*.

contact pad: Replaceable metal pad, usually made of braided copper and/or lead, that prevents electrical arcing between the headstock and test object during a head shot.

continuous technique: Technique of magnetic particle testing, a test sequence where the particles flow over the test object only during active magnetization.

contour probe: In magnetic particle testing, yoke with legs adjustable for test objects of various shapes.

contrast: Difference in color or brightness between indication and background.

cosine law: Physical law stating that the illumination of a surface varies as the cosine of the incidence angle. Maximum illumination is obtained when the source is perpendicular to the surface.

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.⁴

crack: (1) Break, fissure or rupture, sometimes V shaped in cross section and relatively narrow. By convention, a discontinuity is called a *crack* if it is at least three times longer than it is wide. (2) Propagating discontinuity caused by fatigue, corrosion or stresses such as heat treating or grinding. May be difficult to detect unaided because of fineness of line and pattern (may have a radial or latticed appearance).^{5,6}

curie point (T_c): Temperature at which a phase transformation causes ferromagnetic materials to lose their magnetic properties.

current flow technique: Circular magnetization of a test object within a short period of time by passing electric power through the test object with prods, or the headstock and tailstock of a stationary unit. See also *circular magnetization* and *right hand rule*. Compare *magnetic flow technique*.

current induction technique: See *toroidal magnetization*.

cycle: Single period of a waveform or other variable.⁴

D

dark adaptation: Time required for the pupils to dilate and for the two types of photoreceptors in the retina to change chemical balance. After a finite amount of time, an inspector will transition from photopic vision to mesopic or scotopic low illumination vision.

defect: Discontinuity whose size, shape, orientation or location (1) makes it detrimental to the useful service of its host object or (2) exceeds an accept/reject criterion of an applicable specification. Some discontinuities do not exceed an accept/reject criterion and are therefore not defects. Compare *crack*; *discontinuity*; *indication*.^{5,6}

demagnetization: Reduction of residual magnetism to an acceptable level, generally less than 0.2 to 1.0 mT (2 to 10 G). See also *demagnetizing coil* and *direct current downcycle demagnetization*.

demagnetizing coil: Solenoid or coil carrying the current to be used for demagnetization. Current waveform may be alternating for pass-through solenoids, or a rectified current when a multiple-step downcycle demagnetization process is used. Some residual magnetization may remain in large parts magnetized with direct current or rectified current, but subsequently demagnetized with alternating current. See also *direct current downcycle demagnetization*.

demagnetizing factor: See *self-demagnetizing factor*.

density: Mass per unit volume, measured in kilograms per cubic meter ($\text{kg} \cdot \text{m}^{-3}$).

depth of penetration: See *skin effect*.

diamagnetic material: Substance with a magnetic permeability less than 1 that weakly repels an external magnetic field.

diffuse indication: Particle cluster not clearly defined — for example, indication from a subsurface discontinuity.

direct current: Electricity that flows continuously in one direction through a conductor. The only true source of direct current is a battery, although some rectified power waveforms may resemble direct current. See also *full-wave current* and *half-wave current*.

direct current downcycle

demagnetization: Massaging the magnetism of a component down to an acceptable level through a 25-step to 30-step process, where the persistence of one polarity is overcome in decreasing steps by a field reversing at each step.

discontinuity: Interruption in the physical structure or configuration of a test object. After nondestructive testing, a discontinuity indication can be interpreted to be a *flaw* or a *defect*.¹⁰ Compare *defect*; *indication*.^{5,6}

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.⁴

domain: Macroscopic dipole substructure within a ferromagnetic material permanently magnetically saturated. Domains are randomly oriented in a demagnetized material, but their orientation may be preferentially rotated through the application of an external field.

downcycle: See *direct current downcycle demagnetization*.

dry powder: Ferromagnetic particles, larger than those used in wet suspensions, introduced to the test object surface by dusting or puffing.

dry technique: Magnetic particle test technique, generally used with portable equipment, where the ferromagnetic particles are applied as powder.

dual-use particle: Magnetic particle coated with pigment that provides contrast when viewed under controlled levels of ambient white light but that also fluoresces under ultraviolet radiation. Testing with fluorescent particles is performed under low ambient lighting and controlled ultraviolet radiation. Compare *dual-use particle*; *visible particle*.

E

eddy current: Electrical current induced in a conductor by a time varying magnetic field.⁴

electric arc welding: Joining of metals by heating with electric arc. Also called *arc welding*.³

electromagnet: Ferromagnetic core surrounded by a coil of wire that temporarily becomes a magnet when an electric current flows through the wire.⁴

encircling coil: See *coil technique*.

endoscope: See *borescope*.

equivalent 20/20 near vision acuity: Vision acuity with remote viewing or other nondirect viewing that approximates 20/20 direct viewing closely enough to be considered the same for visual testing purposes.³

equivalent sphere illumination: Level of perfectly diffuse (spherical) illuminance that makes the visual task as photometrically visible within a comparison test sphere as it is in the real lighting environment.³

evaluation: Process of deciding the severity of a condition after an indication has been interpreted. Evaluation determines if the test object should be rejected or accepted. See also *indication* and *interpretation*.⁵

eye sensitivity curve: See *photopic vision*.

F

false indication: Test indication that could be interpreted as originating from a discontinuity but that actually originates where no discontinuity exists in the test object. Distinct from a *nonrelevant indication*. Compare also *defect*.⁴

farsightedness: Vision acuity functionally adequate for viewing objects at a distance, generally at or farther than an arm's length. Also called hyperopia.³ Compare *nearsightedness*.

ferromagnetic material: Material such as iron, nickel or cobalt whose relative permeability is considerably greater than unity, depends on the magnetizing force and often exhibits hysteresis. Materials that are most strongly affected by magnetism are called *ferromagnetic*.⁴

field flow technique: See *magnetic flow technique*.

fill factor: Convenient quantity for characterizing how closely the outside diameter of a specimen matches the inside diameter of the magnetizing coil. With a high fill factor, the ratio of the cross sectional area of the coil divided by the cross sectional area of the specimen is less than 2; intermediate, 2 to 10; low, greater than 10.

fillet weld: Weld that joins the edges of workpieces at right angles.

flash magnetization: See *capacitor discharge technique*.

flash point: Lowest temperature at which a substance will form an ignitable mixture in air. The value varies with circumstances.

flaw: Rejectable or unintentional anomaly.⁴ See also *defect* and *discontinuity*.⁴

fluorescence: Luminescent phenomenon exhibited by some substances where higher energy electromagnetic waves are absorbed and reemitted as lower energy waves. The emission ceases as soon as the exciting energy is removed. Different from phosphorescence, which will continue to emit after the exciting energy is removed. In magnetic particle testing, pigments coating the magnetic particles are excited by invisible UV-A radiation and emit visible light.

fluorescent particle: Magnetic particle coated with pigment that fluoresces when excited with UV-A radiation. Testing with fluorescent particles is performed under low ambient lighting and controlled ultraviolet radiation. Compare *dual-use particle*; *visible particle*.

flux: Convenient concept for visualizing the vector field of magnetic induction that comprises a magnetic field. Flux lines form closed loops that do not cross. Magnetic flux is governed by the density of flux lines. The number of flux lines is expressed in weber (Wb), where 1 Wb = 10⁸ maxwell (Mx). The density of flux lines is expressed in tesla (T), where 1 T = 10⁴ gauss (G).

flux density: See *magnetic flux density*.

flux indicator: See *shared flux indicator*.

flux leakage field: Magnetic field that leaves or enters the surface of an object.⁴

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.⁴

flux meter: Device that measures total change in magnetic flux density by monitoring the voltage induced in a coil.⁸ See also *tesla meter*.

footcandle (ftc): Non-SI unit of illuminance, where
 $1 \text{ ftc} = 1 \text{ lm} \cdot \text{ft}^{-2} = 10.76 \text{ lx}$.

footlambert (ftl): Non-SI unit of luminance, where $1 \text{ ftl} = 3.426 \text{ cd} \cdot \text{m}^{-2}$.

fracture mechanics: Field of solid mechanics that deals with behavior of cracked bodies subjected to stress and strain.

frequency: Number of times per second that a cyclical waveform repeats. The unit of frequency is hertz (Hz).

full-wave current: Single-phase or three-phase alternating current converted to produce unidirectional current. Rectified current contains more amplitude variation, or ripple, than direct current from a battery.

furring: Buildup of dry magnetic particles at magnetic poles resulting from overmagnetization of the test object.

G

gas metal arc welding: Inert gas shielded metal joining process that uses a continuous and consumable wire electrode. Also called MIG (metal inert gas) welding. Compare *gas tungsten arc welding* and *shielded metal arc welding*.

gas tungsten arc welding: Inert gas shielded metal joining process that uses a nonconsumable tungsten electrode. Filler material, when needed, is manually fed into the molten weld puddle. Also called *tungsten inert gas welding*. Compare *gas metal arc welding*; *shielded metal arc welding*.

gauss (G): Old CGS unit of magnetic flux density denoting one flux line, or maxwell, passing through one square centimeter. The preferred unit of flux density is the tesla (T), where $1 \text{ T} = 10^4 \text{ G}$.

gauss meter: See *tesla meter*.

general examination: In personnel qualification, a 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 test 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.)⁴

glare: Excessive brightness (or brightness varying by more than 10:1 within the field of view) that interferes with observation or interpretation of a test response. Glare may be caused by reflection, whether specular (smooth surface) or diffuse (rough surface), of light or radiation sources.

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 oriented 90 degrees to the direction of grinding.⁴

H

half-wave current: Power waveform rectified from single-phase alternating current to produce a pulsating unidirectional field.

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 current flows along a rectangular conductor subjected to a transverse magnetic field.⁴

hall effect detector: Semiconductor element that produces an output electromotive force proportional to the product of the magnetic field intensity and a biasing current.⁴

headstock: One of two points on a wet horizontal unit, often equipped with a pneumatic ram, which contacts and supports the test object during application of the current flow technique.

head shot: See *current flow technique*.

heat affected zone: Base metal that was not melted during brazing, cutting or welding but whose microstructure and physical properties were altered by the heat.⁴

heat treatment: Heating and cooling a metal or alloy in such a way as to obtain desired conditions or properties. Heating for the sole purpose of working is excluded from this definition.³

hertz (Hz): Measurement unit of frequency, equivalent to one cycle per second.⁴

horseshoe magnet: U shaped bar magnet. See also *keeper*.

human factors: Factors in the overall test sensitivity based upon mental and physical condition of the inspector, training, experience level and the physical conditions under which the inspector must work.

hyperopia: See *farsightedness*.

hysteresis: Lagging of a ferromagnetic test object's magnetization under the influence of a changing external magnetic field intensity; phenomenon exhibited by a magnetic system wherein its state is influenced by its previous history.⁴

hysteresis loop: Curve showing flux density B plotted as a function of magnetizing force H as H is increased to the saturation point in both negative and positive directions sequentially. The curve forms a characteristic loop.⁴

I

IACS: International Annealed Copper Standard.

illuminance: Intensity of radiant energy in the visible light spectrum. Illuminance is measured in footcandles or lux.

incremental permeability: Ratio of the change in magnetic induction to the corresponding change in magnetizing force.⁴

indication: Nondestructive test equipment response to a discontinuity that requires interpretation to determine its relevance.⁴ In magnetic particle testing, a visible accumulation of magnetic particles that serves as evidence of a magnetic leakage field. See also *defect*, *discontinuity*, *false indication* and *nonrelevant indication*.

induced current magnetization: Noncontact means for testing delicate ring shaped objects for circumferential discontinuities. The technique is based on the fact that a time varying current passing through an internal conductor, often a soft iron or laminated core, self-induces an encircling magnetic field. This time varying magnetic field will induce a secondary current circling through the ring. This secondary current then self-induces the toroidal magnetic field used for testing. See also *right hand rule*.

inductance: Property of electric circuit, by which current in it or in a nearby circuit creates magnetic flux in the other circuit. Inductance is measured in henries, where one henry equals one weber per ampere ($1 \text{ H} = 1 \text{ Wb} \cdot \text{A}^{-1}$). See also *self-inductance*.

initial permeability: Slope of the induction curve at zero magnetizing force as a test object begins to be magnetized from a demagnetized condition (slope at the origin of the BH curve before hysteresis is observed).⁴

internal conductor: Rod of conductive material threaded through a hole in a cylindrical test object to induce circular magnetic flux. An internal conductor may be centered in the hole (a central conductor) or be offset near or touching one side of the cylinder's inside surface.

intergranular stress corrosion crack: 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).⁴

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.⁴

interpretation: Determination of the source, significance and relevance of test indications.^{5,6}

inverse square law: Physical law for a point source of energy. The quantity or strength is inversely proportional to the square of the distance from the origin.

iris: Ring of variable area around the pupil and in front of the lens of the eye. The surface area of the iris adjusts spontaneously to change the amount of light entering the eye.³

irradiance: Radiant power falling upon a known surface area at a given angle. In nondestructive testing, the unit for irradiance of a UV-A source is microwatt per centimeter squared ($\mu\text{W} \cdot \text{cm}^{-2}$) and maximum irradiance occurs when the source and surface are perpendicular. See also *radiometer*.

J

jaeger eye chart: Eye chart used for near vision acuity examinations.³

K

keeper: Ferromagnetic material placed across the pole faces of a permanent horseshoe magnet to reduce the reluctance of the gap and to prevent loss of magnetism.

ketos ring: See *test ring*.

kinematic viscosity: Ratio of absolute viscosity divided by the liquid's density. Kinematic viscosity is often reported in centistokes.

L

$L \cdot D^{-1}$ ratio: Convenient means for expressing the shape of a test object in terms of length L divided by diameter D . In magnetic particle testing, ratio used to judge whether a test object is appropriate for coil magnetization or demagnetization alone or whether pole extensions or stacking is required. See also *self-demagnetizing factor*.

lambert cosine law: See *cosine law*.

laminated pole pieces: See *articulated pole pieces*.

leach: See *leech*.

leaked visible light: Unwanted electromagnetic radiation that has a wavelength between 400 and 800 nm that is generated by the UV-A source but not filtered out of the emission spectrum. Leaked visible light is generally perceived as purple or dark blue light and will not be accurately measured using a photometric sensor. See also *light contamination, photometer, radiometer, UV-A, UV-A filter* and *visible light*.

leakage field: See *flux leakage field*.

leech: Permanent magnetic or electromagnetic accessory used to ensure adequate electrical contact during current flow magnetization. Sometimes spelled *leach*.

lifting power: In magnetic particle testing, the mass of a ferromagnetic bar that a yoke can suspend through attraction. Often this mass is provided as a minimum that the yoke must meet or exceed.

light: Electromagnetic radiation that falls within the human eye's response range. See also *photopic vision*.

light contamination: Unwanted visible light present in darkened test area. Sources may include gaps in curtains, leaked visible light from the UV-A source or fluorescence from the inspector's clothing.

light meter: See *photometer*. Compare *radiometer*.

limited certification: Individuals certified only for specific operations; usually called *limited Level* (I, II or III) or designated as having *limited certification* because they are not qualified to perform the full range of activities expected of personnel at that level of qualification.³

lines of force: See *flux*.

longitudinal magnetic field: Active or residual magnetization oriented along the longest axis of the part. See also *longitudinal magnetization* and *magnetic flow technique*.

longitudinal magnetization: Result of magnetic flow technique where induced flux lines flow between the poles of an electromagnet or pair of permanent magnets.

lumen (lm): SI photometric unit of luminous flux, weighted according to the photopic vision response. One lumen equals the light emitted by one candela (cd) point source into one steradian (sr) solid angle ($1 \text{ lm} = 1 \text{ cd} \cdot \text{sr}^{-1}$).

luminance: Photometric brightness of a light source as defined by the density of its luminous intensity. Luminance is a measure of the luminous flux per unit solid angle per unit area in a given direction and is reported in candela per square meter ($\text{cd} \cdot \text{m}^{-2}$).

luminous intensity: Measure of a light source's power output per unit solid angle emitted or reflected from a point, when weighted by the photopic spectral luminous efficiency response curve. Luminous intensity is measured in candela. Compare *luminance*.

lux (lx): SI unit of illuminance, equal to one lumen per square meter ($1 \text{ lx} = 1 \text{ lm} \cdot \text{m}^{-2}$).

M

magnetic circuit: Path followed by flux lines that may include the test object, any air gaps and an electromagnetic or permanent magnet yoke.

magnetic field: Energy vector field surrounding a magnet or electric circuit.

magnetic field indicator: See *pocket field indicator*.

magnetic field intensity (H): Magnitude of the vector field surrounding a magnetic dipole,⁹ in ampere per meter. Sometimes called *magnetic field strength*.

magnetic flow technique: Longitudinal magnetization technique where at least part of the test object completes a magnetic circuit. See also *longitudinal magnetization* and *yoke*.

magnetic flux: See *flux lines*.

magnetic flux density (B): Amount of magnetic induction passing perpendicularly through a given area, measured in tesla.

magnetic flux leakage testing: Nondestructive test technique where induced magnetism in a ferromagnetic sample forms localized poles at surface. Near-surface discontinuities are indicated by a signal in an induction coil or hall element; if they are indicated by magnetic particles, the technique is called *magnetic particle testing*.

magnetic gradient: Change in magnetic field intensity ($A \cdot m^{-2}$).

magnetic particle testing:

Nondestructive test technique where induced magnetism in a ferromagnetic sample forms localized poles at surface and near-surface discontinuities indicated by a finely divided iron based powder. Compare *magnetic flux leakage testing*.

magnetic particles: Finely divided ferromagnetic powder of proper size, shape, relative permeability, visibility and retentivity for use in a test.

magnetic pole: One of two opposite ends of a dipole where flux enters or leaves a magnetized object. Any location where flux enters or leaves the test object.

magnetic rubber: Replica casting medium containing magnetic particles, which when cured and removed from a properly magnetized recess, provides a permanent mold with visible indications.

magnetic saturation: Result of complete domain alignment where an increase in the coercive field H produces no change in flux density B .

magnetic stripe card: In magnetic particle testing, a credit card sized device with encoded magnetic reversals of varying strength for regular evaluation of bath sensitivity. See also *particle concentration*. Compare *settling test*.

magnetic writing: Nonrelevant indication that may be caused when two magnetized objects come into contact.

magnetization: (1) Induced dipole moment per unit volume of a solid. (2) Act of inducing a magnetic field in a ferromagnetic object.

magnetizing force: Magnetomotive force per unit length of a magnetic circuit. Measured in ampere turns per meter ($At \cdot m^{-1}$).

magnetomotive force: Magnetic field intensity, measured in air or vacuum in ampere turns.

magnetometer: See *pocket field indicator*.

magnitude: Absolute value of a complex quantity (number) without reference to the phase of the quantity.⁴

material safety data sheet (MSDS):

Document that contains information on safety and health in storage, handling, use, cleanup and disposal of substances. Manufacturers of testing materials are required to provide material safety data sheets to users in accordance with the *OSHA Hazard Communication Standard*.

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

$$(3) \quad \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$(4) \quad \nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J}$$

$$(5) \quad \nabla \cdot \mathbf{B} = 0$$

$$(6) \quad \nabla \cdot \mathbf{D} = \rho$$

where \mathbf{B} is magnetic flux density, \mathbf{D} is electric flux density, \mathbf{E} is electric field intensity, \mathbf{H} is magnetic field intensity, \mathbf{J} is current density, t is time, ρ is volume charge density and ∇ is the del operator.⁴

mesopic vision: Intermediate state of dark adaptation where retinal cones and rods work together in semidark conditions. This state would be expected in typical fluorescent nondestructive evaluation applications. See also *photopic vision* and *scotopic vision*.

MIG welding: See *gas metal arc welding*.

model, analytical: Mathematical representation of a process or phenomenon.⁴

multidirectional magnetization: Two or more magnetic fields in different directions imposed on a test object sequentially and in rapid succession through phase control of the supplied current. See also *phase* and *swinging field magnetization*.

myopia: See *nearsightedness*.

N

NDE: (1) Nondestructive examination. (2) Nondestructive evaluation. See *nondestructive testing*.

NDI: Nondestructive inspection. See *nondestructive testing*.

NDT: See *nondestructive testing*.

nearsightedness: Vision acuity functionally adequate for viewing objects nearby, generally within an arm's length. Also called myopia.³ Compare *farsightedness*.

near-surface discontinuity: Subsurface interruption in the physical structure or configuration of a test object that is close to, but not breaking, the test object's surface. (This sense of *near surface* differs from that in methods that distinguish a test object's near surface from its far surface, a distinction rarely made in magnetic particle testing.)

noise: Component of physical quantity, such as voltage, that provides nonrelevant information. Compare *signal*.

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).^{5,6} Sometimes called *nondestructive evaluation*, *nondestructive examination* or *nondestructive inspection*.

nonferromagnetic material: Material not magnetizable and essentially not affected by magnetic fields.⁴

nonrelevant indication: Test response caused by sample geometry or by a physical condition that is not a discontinuity.

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.⁴

O

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

ohm (Ω): Measurement unit of electrical resistance.⁴

oil country tubular goods (OCTGs): Hollow cylindrical components, such as pipes, used to convey petroleum and related products.⁴

P

parallel magnetization: Dubious practice of imparting circular magnetization in a sample near a current carrying conductor. Compare *internal conductor*.

paramagnetic material: In electromagnetic testing, a material that has a relative permeability slightly greater than unity and is practically independent of the magnetizing force.⁴

particle concentration: Amount of powder suspended within a known sample volume of bath. Typically measured using a settling test, or through evaporation and weighing. See also *centrifuge tube*.

percent International Annealed Copper Standard (%IACS):

Traditional measurement of *conductivity* σ as a percentage of the conductivity of pure copper, arbitrarily rated at 100 percent.⁴ In SI, conductivity is measured in siemens per meter ($\text{S}\cdot\text{m}^{-1}$). See also *conductivity*; *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.⁴

permanent magnet: Material with high retentivity, which maintains magnetization after a coercive field has been removed. In magnetic particle testing, permanent magnet yokes must also have a high coercivity.

permeability (μ): (1) Ability of a material to be magnetized, measured as increase in flux density. (2) Ratio of magnetic induction B over magnetizing force H . Absolute permeability in SI units is measured in henries per meter ($\text{H}\cdot\text{m}^{-1}$). See also *relative permeability* and *permeability of free space*.

permeability of free space (μ_0):

Calculation constant describing the ratio of magnetic induction B to magnetizing force H within a vacuum. $1 \mu_0 = 4 \times 10^{-7} \text{ H}\cdot\text{m}^{-1}$. See also *permeability* and *relative permeability*.

pH: A measure of the acidity or alkalinity of a solution. Negative of $\log C$, where C is the concentration of hydrogen ions. Values lower than 7.0 are acidic; values equal to 7.0 are neutral; values higher than 7.0 are alkaline.

phase: (1) A circuit conductor carrying alternating current of a given frequency, as in one-phase or three-phase power. (2) Point on a 360-degree harmonic power waveform (thyristors, for example, vary total power output through phase control).

photochromic lens: Eyeglass material that automatically darkens to reduce light transmission when exposed to ultraviolet radiation.

photometer: Device used to measure illuminance. The sensor is filtered such that its response closely matches the spectral responsivity curve of the human eye. In nondestructive testing, photometers measure lux. Compare *radiometer*.

photometry: Study and measurement of electromagnetic radiation with wavelengths between 400 and 800 nm, within the human eye's spectral responsivity. See also *photometer* and *photopic vision*. Compare *radiometry*.

photopic vision: Average spectral responsivity curve of the human eye when adapted to well lit conditions (greater than $0.034 \text{ cd}\cdot\text{m}^{-2}$). The photopic spectral luminous efficiency response curve is governed by an averaged retinal cone response with sensitivity peaks centered at about 555 nm.

pie gage: One type of shared flux indicator in the form of a handle mounted disk comprised of ferromagnetic wedges surrounded by a copper matrix. When properly demagnetized before use the space between wedges provides artificial discontinuities at 0, 45 and 90 degrees and provides a measure of magnetic flux direction during dry powder testing.

pocket field indicator: Small, hand held device used to display the intensity of uniform external magnetic flux as angular deflection of a display needle. The device contains a permanent reference magnet coupled to a movable, field sensing magnet, and some units may be calibrated.

pole: See *magnetic pole*.

powder blower: Compressed air device used to deliver a cloud of dry magnetic particles to the surface of a test object.

powder bulb: Container compressed by hand to deliver a cloud of dry magnetic particles to the surface of a test object.

practical examination: In certification of nondestructive testing personnel, a hands-on examination using test equipment and sample test objects.³ Compare *general examination* and *specific examination*.

probability of detection (PoD): Statistical analysis of a specific test procedure indicating how likely a given discontinuity length may be reliably found.

probe: See *transducer*.

prod magnetization: See *current flow technique*.

prods: Handheld electrodes for transmitting magnetizing current from a portable power source to the test object. See also *leech*.

pseudoisochromatic plates: Testing device used for color vision examinations. Each plate bears an image that would be difficult for the examinee to see if their color vision was impaired.³

pulse magnetization: See *capacitor discharge technique*.

pupil: Aperture in the center of an eye's iris, through which light focused by the lens passes.³

Q

qualification: Process of demonstrating that an individual has the required amount and the required type of training, experience, knowledge and abilities.^{5,6} See also *certification* and *qualified*.

qualified: Having demonstrated the required amount and the required type of training, experience, knowledge and abilities.^{5,6} See also *certified* and *qualification*.

quality: Ability of a process or product to meet specifications or to meet the expectations of its users in terms of efficiency, appearance, reliability and ergonomics.^{5,6}

quality assurance: Administrative actions that specify, enforce and verify quality.^{5,6}

quality control: Physical and administrative actions required to ensure compliance with a quality assurance program. Quality control may include nondestructive testing in the manufacturing cycle.^{5,6}

quantitative quality indicator (QQI): Shim that has an artificial discontinuity and is held in intimate contact with a test object's surface during active magnetization to indicate that proper magnitude and direction of magnetic induction have been obtained for testing. The artificial discontinuity may be circular or linear and is defined in terms of percent of total shim thickness.

quick break: Sudden cessation of magnetizing current. A quick break is needed when using three-phase full-wave rectified alternating current during coil or induced current magnetization. The rapid change in current produces strong magnetic induction during toroidal magnetization and reduces the disturbing flux near poles for sensitive testing of the test object's ends in coil magnetization.

R

radial: Of or pertaining to direction from center of a sphere or cross section of a cylindrical object to its surface, and perpendicular to its axis. Compare *axial* and *tangential*.

radiometer: Device used to measure irradiance. In nondestructive testing, radiometers are used to measure UV-A output, or leaked visible light, in microwatt per square centimeter ($\mu\text{W}\cdot\text{cm}^{-2}$). See also *irradiance*. Compare *photometer*.

radiometry: Study and measurement of electromagnetic radiation emitted by a source or falling upon a surface.

recommended practice: Set of guidelines or recommendations.⁴

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.⁴

recommended practice: Set of guidelines or recommendations.^{5,6}

Recommended Practice No. SNT-TC-1A: Set of guidelines published by the American Society for Nondestructive Testing, for employers to establish and conduct a qualification and certification program for nondestructive testing personnel.^{5,6}

rectified alternating current: See *half-wave current* and *full-wave current*.

reference standard: (1) Test object containing known discontinuities representing accept or reject criteria. (2) Sample test object selected for reference.⁵

relative permeability (μ_r): Unitless ratio of a material's permeability to the permeability of free space.

relevant indication: In nondestructive testing, an indication from a discontinuity or condition and requiring evaluation.⁵

reluctance: Resistance of a material to changes in magnetization. Reciprocal of permeability.

rejection level: Value established for a test signal above or below which test objects are rejectable or otherwise distinguished from the remaining objects. This level is different from the *rejection level* as defined for ultrasonic and other test systems.⁴

remanent magnetism: See *residual magnetic field*.

residual magnetic field: Magnetization remaining in a ferromagnetic material after magnetizing force H is reduced to zero.

residual technique: Testing procedure used only with highly retentive materials where a remnant magnetic field is relied on to attract magnetic particles. Compare *continuous technique*.

resistance, electrical (R): Opposition to flow of electric current through material; ratio of voltage to current. Measured in ohms (Ω). Inversely related to *conductance*:

$$(7) \quad R = \frac{1}{G} = \frac{\rho L}{A}$$

where A is the conductor's cross sectional area (square meter), G is conductance (siemens), L is the length of the conductor (meter) and ρ is resistivity (ohm meter).⁴

resistivity (ρ): Ability of material to resist electric current. Measured in ohm meter ($\Omega \cdot m$), which is the resistance of a cube made of the material whose dimensions are 1 m on each side. Inversely related to *conductivity* σ (siemens per meter):⁴

$$(8) \quad \rho = \frac{1}{\sigma}$$

resolution: An aspect of image quality pertaining to a system's ability to reproduce objects, often measured by resolving a pair of adjacent objects or parallel lines.⁶

retentivity: Material's ability to maintain remnant magnetism in the absence of a coercive field.

retina: Rear portion of the eyeball, opposite the pupil, where light sensitive rods and cones are present.

right hand rule: Technique for visualizing the relationship between a flowing current and its induced magnetic field. When the right hand is closed in a fist with the thumb extended and when current flows out along the thumb, the fingers represent the self-induced magnetic field.

rise time: Amount of time for a current source to reach its set point.

rod cells: Low light photoreceptors concentrated toward the outer region of the retina. Rods assist with mesopic vision and are responsible for scotopic night vision. Compare *cone cells*.

root mean square (rms): Statistical measure of the magnitude of a varying quantity, such as current. Square root of the mean square of a set of measures, usually a time series.

S

saturation: See *magnetic saturation*.

scalar: Quantity completely specified by a single number and unit.⁴

scotopic vision: Average spectral responsivity curve of the human eye when adapted to very dark conditions (less than 3×10^{-5} cd·m⁻²). Illumination levels for scotopic vision are below the sensitivity of retinal cones, so no color perception is possible.

self-demagnetizing factor: Estimate of the resistance of a test object to magnetization due to the proximity of magnetic poles of opposite polarity. For coil magnetization, the internal magnetization within a low $L \cdot D^{-1}$ ratio test object is opposite of the coil's magnetic field and a lower distance between poles results in a greater internal resistance.

self-inductance: Ratio of magnetic flux formed around a conductor to the amount of current passing through a straight or coiled conductor. Self-inductance is measured in henries, where one henry equals one weber per ampere (1 H = 1 Wb·A⁻¹). See also *inductance*.

sensitivity: See *probability of detection*.

sensor: Device that detects a material property or mechanical behavior (such as radiation or displacement) and converts it to an electrical signal. *Probe; transducer*.⁵

settling test: One procedure used to determine the concentration of magnetic particles in a new bath or to check for contamination or other bath problems. See also *centrifuge tube* and *particle concentration*. Compare *magnetic stripe card*.

shared flux indicator: Device held in intimate contact with test object during active magnetization to show the direction of magnetic induction. Examples include the berthold penetrometer, magnetic flux indicator strip and pie gage.

shielded metal arc welding: Metal joining process that uses a consumable flux coated electrode. The flux both covers the molten weld pool and forms the protective shielding gas. Also called stick welding. Compare *gas metal arc welding* and *tungsten metal arc welding*.

shim: Indicator of magnetic field orientation, consisting of thin foil of high permeability material having artificial notch discontinuities.

shot: In magnetic particle testing, the period of time when current is flowing through the test object. Shot duration and the number of shots required for testing may be varied. See also *current flow technique*.

SI (International System of Units): Measurement system in which the following seven units are basic: meter, mole, kilogram, second, ampere, kelvin and candela.^{5,6}

siemens per meter (S·m⁻¹): SI unit of conductivity.

signal: Physical quantity, such as voltage, that contains relevant information.⁴

signal-to-noise ratio: Ratio of signal values (responses that contain relevant information) to baseline noise values (responses that contain nonrelevant information).⁴

silicon controlled rectifier: Solid state electronic component used to vary power output in an arcless manner. The power waveform from a silicon controlled rectifier will contain spikes and conversion between peak, root mean square and average is not straightforward across the output range.

skin depth: 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.⁴ See also *skin effect*.

skin effect: Term used to describe the penetration ability of cyclical current or magnetization as a function of frequency, conductivity and relative permeability. In magnetic particle testing, skin effect refers to alternating current's inability to penetrate deeper than 1 to 3 mm (0.04 to 0.12 in.) with typical testing variables.¹⁰ See also *skin depth*.

slurry: See *bath*.

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

specific examination: In certification of nondestructive testing personnel, a written examination that addresses the specifications and products pertinent to the application.³ Compare *general examination* and *practical examination*.

specific gravity: Unitless ratio of the density of a material divided by the density of water. Water has a density of about 1 g·cm⁻³, or 1000 kg·m⁻³.

specification: Set of instructions or standards invoked to govern the results or performance of a specific set of tasks or products.^{5,6}

spectral irradiance: Measure of energy emitted by a radiation source as function of wavelength. Units of spectral irradiance are in watts per meter squared and are often plotted versus wavelength.

spectral luminous efficiency: See *spectral responsivity*.

spectral responsivity: Measure of a photometric or radiometric sensor's sensitivity over a wavelength range of interest, often presented as percent versus wavelength. Photometric sensors should exhibit a bell shaped spectral responsivity curve over the visible light range, whereas radiometric sensors may exhibit a flat or other response curve.

standard: (1) Reference object used as a basis for comparison or calibration. (2) Concept established by authority, custom or agreement to serve as a model or rule in the measurement of quantity or the establishment of a practice or procedure.^{5,11}

standard depth of penetration: See *skin depth*.

standardization, instrument: Adjustment of instrument readout before use to a specified reference value.⁴

stick welding: See *shielded metal arc welding*.

stress concentration: Region where force per unit area is elevated, often because of geometric factors or cracks. Also known as a *stress raiser*.

stringer: In wrought materials, an elongated configuration of microconstituents or foreign material aligned in the direction of working. Commonly, the term is associated with elongated oxide or sulfide inclusions in steel.³

subsurface discontinuity: Discontinuity not open to the surface. See also *near-surface discontinuity*.

susceptibility: Dimensionless property describing a material's response to an external magnetic field.

suspension: See *bath*.

suspension vehicle: See *carrier fluid*.

swinging field magnetization: One form of multidirectional magnetization where two time varying magnetic fields are combined such that the resultant vector magnetization rapidly rotates through an angle. See also *multidirectional magnetization*.

T

tangential: Of or pertaining to a direction impinging on a curved surface of an object and perpendicular to the radius at the point where it impinges. Compare *axial* and *radial*.

tesla (T): SI derived unit of measure for magnetic flux density. $1\text{ T} = 1\text{ Wb}\cdot\text{m}^{-2} = 10^4\text{ G}$.

tesla meter: Magnetometer used to measure active or residual magnetic induction in the location and direction of interest. See also *flux meter*, *hall effect*.

test object: Hollow, ring shaped specimen, typically made of 01 tool steel, containing artificial subsurface drilled through-hole discontinuities. The ring is used to compare the daily performance of a wet horizontal test unit or to evaluate the sensitivity of dry powders when magnetized using three-phase full-wave rectified current.

test object: Physical part or specimen subject to nondestructive testing.

threshold level: Setting of an instrument that causes it to register only those changes in response greater or less than a specified magnitude.⁴

thyristor: See *silicon controlled rectifier*.

TIG welding: See *gas tungsten arc welding*.

toroidal magnetization: See *induced current magnetization*.

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.⁴

tubing string: Pipe with which oil or gas has contact as it is brought to the earth's surface.⁴

U

ultraviolet radiation: Electromagnetic radiation with wavelengths between 100 and 400 nm. See also *irradiance* and *UV-A*. Fluorescent nondestructive testing uses UV-A and safe exposure limits for ultraviolet radiation and blue light hazard are available through the American Conference of Governmental Industrial Hygienists.

ultraviolet source: Term for the device providing excitation energy for fluorescent materials. See *UV-A radiation source*.

Unified Numbering System: Alphanumeric system for identifying alloys according to a registry maintained by ASTM International and SAE International.⁴

UV-A: Electromagnetic radiation with wavelengths between 315 and 400 nm. Fluorescent nondestructive testing has historically used ultraviolet energy centered at 365 nm. See also *irradiance* and *radiometer*.

UV-A filter: Device that is used to modify the emission spectrum from a radiation source to eliminate visible light and higher energy ultraviolet energy, while allowing the desired long wavelength ultraviolet radiation to pass through.

UV-A radiation source: Preferred term for the device providing excitation energy for fluorescent materials.

V

vector quantity: Any physical quantity whose specification involves both magnitude and direction and that obeys the parallelogram law of addition.⁴

viscosity: Measure of the resistance of liquid to deform under shear stress. See also *kinematic viscosity*.

visible light: Radiant energy with a wavelength between 400 and 800 nm as measured in photometric units of lux.

visible particle: Common term describing finely divided powder for use in nonfluorescent magnetic particle tests. The particles may be their natural color or may be coated to enhance contrast. Testing using visible particles is performed under a controlled level of ambient lighting and typically does not need any ultraviolet light.

vision acuity: Quantitative measure of the acuteness of vision.

visual efficiency: Reliability of a visual system. The term *visual efficiency* uses 20/20 near vision acuity as a baseline in the United States for 100 percent visual efficiency.³

visual field: Locus of objects or points in space that can be perceived when head and eyes are kept fixed. The field may be monocular or binocular.³

visual perception: Interpretation of impressions transmitted from the retina to the brain in terms of information about a physical world displayed before the eye. Visual perception involves any one or more of the following: recognition of the presence of something (object, aperture or medium); identifying it; locating it in space; noting its relation to other things; identifying its movement, color, brightness or form.³

visual performance: Quantitative assessment of the performance of a visual test, taking into consideration speed and accuracy.³

visual task: Appearance and immediate background of those details and objects that must be seen for the performance of a given activity. The term *visual task* is a misnomer because it refers to the visual display itself and not the task of extracting information from it.³

volt (V): Measurement unit of electric potential.⁴

W

water, break free: Rinse water, having the ability to cover an entire surface in an unbroken film.³

wavelength: Distance between repeating units of a wave. For example, the distance from one peak to the next peak.

wet horizontal unit: Stationary equipment that provides a measured amount of electric current to a headstock and tailstock, allows bath application and may be equipped with a rigid multiple-turn magnetizing coil.

wet technique: Testing procedure in which the suspended magnetic particles are applied as a well agitated bath.

wetting action: Action of liquid in spontaneously spreading over and adhering to solid surfaces.³

white light: Light combining all frequencies in the visible spectrum and in equal proportions.³

working standard: Work piece or energy source calibrated and used in place of expensive reference standards. In calibrating of photometers, the standard would be a light source.³

Y

yoke: Portable U shaped electromagnet or permanent magnet that induces longitudinal magnetization in the region of the test object between its magnetic poles. See also *articulated pole pieces* and *magnetic flow technique*.

PART 2. Symbols

TABLE 1. Symbols and units used in electromagnetics.

Symbol	Property	SI Unit	SI Symbol
A	magnetic vector potential	weber per meter	$\text{Wb}\cdot\text{m}^{-1}$
$A_x, A_y, A_z, A_R, A_r, A_\theta, A_\phi$	components of vector		
At	(unit)	ampere turn	At
B	magnetic flux density	tesla	T
D	electric flux density	coulomb per square meter	$\text{C}\cdot\text{m}^{-2}$
ds	differential area (vector)	square meter	m^2
$d\ell$	differential length (vector)	meter	m
E	electric field intensity	volt per meter	$\text{V}\cdot\text{m}^{-1}$
F	force	newton	N
f	frequency	cycles per second	Hz
G	conductance	siemens	S
H	magnetic field intensity	ampere per meter	$\text{A}\cdot\text{m}^{-1}$
I	(electric) current	ampere	A
J	current density	ampere per square meter	$\text{A}\cdot\text{m}^{-2}$
J_s	surface current density	ampere per square meter	$\text{A}\cdot\text{m}^{-2}$
L	inductance	henry	H
ℓ	length, distance	meter	m
M	magnetization	ampere per meter	$\text{A}\cdot\text{m}^{-1}$
m	magnetic moment	ampere per meter	$\text{A}\cdot\text{m}^{-2}$
\hat{n}	normal (component of vector)		
$\hat{n}, \hat{Q}, \hat{R}, \hat{r}, \hat{x}, \hat{y}, \hat{z}, \hat{\theta}, \hat{\phi}$	unit vectors	meter	m
P	power	watt	W
P_d	dissipated power	watt	W
P	poyniting vector	watt per cubic meter	$\text{W}\cdot\text{m}^{-3}$
q	electric charge	coulomb	C
R	resistance	ohm	Ω
R	position vector	meter	m
S	area	square meter	m^2
t	time	second	s
V	(electric) potential, voltage	volt	V
V_m	electromotive force	ampere turn	At
v	velocity, speed	meter per second	$\text{m}\cdot\text{s}^{-1}$
W	work	joule	J
w	energy density	joule per cubic meter	$\text{J}\cdot\text{m}^{-3}$
W_e	electric stored energy	joule	J
W_m	magnetic stored energy	joule	J
δ	skin depth	meter	m
$\epsilon, \epsilon_0, \epsilon_r$	(electric) permittivity	farad per meter	$\text{F}\cdot\text{m}^{-1}$
Λ	flux linkage		
μ, μ_0, μ_r	(magnetic) permeability	henry per meter	$\text{H}\cdot\text{m}^{-1}$
ρ	resistivity	ohm meter	$\Omega\cdot\text{m}$
ρ	charge density	coulomb per square meter	$\text{C}\cdot\text{m}^{-2}$
ρ_s	surface charge density	coulomb per square meter	$\text{C}\cdot\text{m}^{-2}$
σ	conductivity	siemens per meter	$\text{S}\cdot\text{m}^{-1}$
τ	tangential component of vector		
X [chi]	magnetic susceptibility		
ω	angular frequency	radian per second	$\text{rad}\cdot\text{s}^{-1}$

Tables 1 and 2 list physical quantities for electromagnetics.

By convention, symbols for constants and variables from the Roman alphabet are printed in italic; vectors representing four-dimensional information are printed in bold. Measurement units are covered in the introduction to this volume.

For physical quantities and properties in materials science, the reader is served by reference books such as the *CRC Handbook of Chemistry and Physics*¹² and Leonard Mordfin's *Handbook of Reference Data for Nondestructive Testing*.¹³

Measurement units and their symbols are covered in the introduction to this volume.

TABLE 2. Physical constants for electromagnetism.

Symbol	Property	Value
ϵ_0	permittivity of free space	$8.8542 \times 10^{-12} \text{ F}\cdot\text{m}^{-1}$
μ_0	permeability of free space	$4\pi \times 10^{-7} \text{ H}\cdot\text{m}^{-1}$
e	charge on one electron	$-1.602 \times 10^{-19} \text{ C}$
c	speed of light (vacuum)	$2.99792 \times 10^8 \text{ m}\cdot\text{s}^{-1}$

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