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Standard Terminology of Symbols and Definitions Relating to Magnetic Testing[1]

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INTRODUCTION

In preparing this glossary of terms, an attempt has been made to avoid, where possible, vector analysis and differential equations so as to make the definitions more intelligible to the average worker in the field of magnetic testing. In some cases, rigorous treatment has been sacrificed to secure simplicity, but it is believed that none of the definitions will prove to be misleading.

It is the intent of this glossary to be consistent in the use of symbols and units with those found in ANSI/IEEE 260-1978 and USA Standard Y 10.5-1968.

Part 1—Symbols Used in Magnetic Testing

Symbol	Term
α	cross-sectional area of *B* coil
A	cross-sectional area of specimen
A'	solid area
B	magnetic induction; magnetic flux density
ΔB	excursion range of induction
B_b	biased induction
B_d	remanent induction
B_{dm}	remanence
B_dH_d	energy product
$(B_dH_d)_m$	maximum energy product
B_Δ	incremental induction
B_i	intrinsic induction
B_m	maximum induction in a hysteresis loop
B_{max}	maximum induction in a flux current loop
B_r	residual induction
B_{rs}	retentivity
B_s	saturation induction
cf	crest factor
CM	cyclically magnetized condition
d	lamination thickness
D_B	demagnetizing coefficient
df	distortion factor
D_m	magnetic dissipation factor
E	exciting voltage
E_1	induced primary voltage
E_2	induced secondary voltage
E_f	flux volts
f	cyclic frequency in hertz
$\mathscr{F}$	magnetomotive force
ff	form factor
H	magnetic field strength
ΔH	excursion range of magnetic field strength
H_b	biasing magnetic field strength
H_c	coercive field strength
H_{ci}	intrinsic coercive field strength
H_{cs}	coercivity
H_d	demagnetizing field strength
H_Δ	incremental magnetic field strength
H_g	air gap magnetic field strength
H_L	ac magnetic field strength (from an assumed peak value of magnetizing current
H_m	maximum magnetic field strength in a hyster esis loop
H_{max}	maximum magnetic field strength in a flux- current loop
H_p	ac magnetic field strength (from a measured peak value of exciting current)
H_t	instantaneous magnetic field strength (coincident with B_{max})
H_z	ac magnetic field strength force (from an assumed peak value of exciting current)
I	ac exciting current (rms value)
I_c	ac core loss current (rms value)
I_{dc}	constant current
I_m	ac magnetizing current (rms value)
J	magnetic polarization
k'	coupling coefficient
ℓ	flux path length
ℓ_1	effective flux path length
ℓ_g	gap length
$\mathscr{L}$ (also ϕN)	flux linkage
$\mathscr{L}_m$	mutual flux linkage
L	self inductance
L_1	core inductance
L_Δ	incremental inductance
L_i	intrinsic inductance
L_m	mutual inductance
L_0	initial inductance
L_s	series inductance
L_w	winding inductance
m	magnetic moment
M	magnetization
m	total mass of a specimen
m_1	active mass of a specimen
N_D	demagnetizing factor

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N_1	turns in a primary winding
N_2	turns in a secondary winding
$N_1 I/\ell_1$	ac excitation
p	magnetic pole strength
$\mathcal{P}$	permeance
P	active (real) power
P_a	apparent power
$P_{a\ (B;f)}$	specific apparent power
P_c	total core loss
$P_{c\ (B;f)}$	specific core loss
$P_{c\Delta}$	incremental core loss
P_e	normal eddy current core loss
$P_{\Delta e}$	incremental eddy current core loss
P_h	normal hysteresis core loss
$P_{\Delta h}$	incremental hysteresis core loss
P_q	reactive (quadrature) power
P_r	residual core loss
P_w	winding loss (copper loss)
P_z	exciting power
$P_{z\ (B;f)}$	specific exciting power
Q_m	magnetic storage factor
$\mathcal{R}$	reluctance
R_1	core resistance
R_w	winding resistance
S	lamination factor (stacking factor)
SCM	symmetrically cyclically magnetized condition
T_c	Curie temperature
w	lamination width
W_h	hysteresis loop loss
$\bar{\alpha}$	linear expansion, coefficient (average)
$\Delta\chi$	incremental tolerance
β	hysteretic angle
γ	loss angle
$\cos\gamma$	magnetic power factor
γ_p	proton gyromagnetic ratio
Γ_m	magnetic constant
δ	density
κ	susceptibility
ac Permeabilities:	
μ_a	ideal permeability
μ_L	inductance permeability
$\mu_{\Delta}L$	incremental inductance permeability
μ_{0d}	initial dynamic permeability
μ_p	peak permeability
$\mu_{\Delta p}$	incremental peak permeability
μ_i	instantaneous permeability
μ_z	impedance permeability
$\mu_{\Delta z}$	incremental impedance permeability
dc Permeabilities:	
μ	normal permeability
μ_{abs}	absolute permeability
μ_d	differential permeability
μ_{Δ}	incremental permeability
μ_{eff}	effective circuit permeability
μ_i	intrinsic permeability
$\mu_{\Delta i}$	incremental intrinsic permeability
μ_m	maximum permeability
μ_0	initial permeability
μ_r	relative permeability
μ_v(also Γ_m)	space permeability
μ_{rev}	reversible permeability
$\mu'/\cot\gamma$	figure of merit
ν	reluctivity
π	the numeric 3.1416
ρ	resistivity
ϕ	magnetic flux
ϕN	flux linkage (see $\mathcal{L}$)
χ	mass susceptibility
χ_0	initial susceptibility
ω	angular frequency in radians per second

Part 2—Definition of Terms Used in Magnetic Testing

ac excitation, $N_1 I/\ell_1$—the ratio of the rms ampere-turns of exciting current in the primary winding of an inductor to the effective flux path length of the inductor.

active (real) power, P—the product of the rms current, I, in an electrical circuit, the rms voltage, E, across the circuit, and the cosine of the angular phase difference, θ between the current and the voltage.

$$P = EI\cos\theta$$

NOTE 1—The portion of the active power that is expended in a magnetic core is the total core loss, P_c.

aging coefficient—the percentage change in a specific magnetic property resulting from a specific aging treatment.

NOTE 2—The aging treatments usually specified are:
(*a*) 100 h at 150°C or
(*b*) 600 h at 100°C.

aging, magnetic—the change in the magnetic properties of a material resulting from metallurgic change due to a normal or specified aging condition.

NOTE 3—This term implies a deterioration of the magnetic properties of magnetic materials for electronic and electrical applications, unless otherwise specified.

air-gap magnetic field strength, H_g—the magnetic field strength required to produce the induction existing at some point in a nonmagnetic gap in a magnetic circuit.

NOTE 4—In the cgs-emu system of units, H_g is numerically equal to the induction existing at such a point and exceeds the magnetic field strength in the magnetic material.

amorphous alloy—a semiprocessed alloy produced by a rapid quenching, direct casting process resulting in metals with noncrystalline structure.

ampere (turn), A—the unit of magnetomotive force in the SI system of units. The symbol A represents the unit of electric current, ampere, in the SI system of units.

ampere per metre, A/m—the unit of magnetic field strength in the SI system of units.

anisotropic material—a material in which the magnetic properties differ in various directions.

anisotropy of loss—the ratio of the specific core loss measured with flux parallel to the rolling direction to the specific core loss with flux perpendicular to the rolling direction.

$$\textit{anisotropy of loss} = \frac{P_{c\ (B;f)\ l}}{P_{c\ (B;f)\ t}}$$

where:

$P_{c\ (B;f)\ l}$ = specific core loss value with flux parallel to the rolling direction, W/lb [W/kg], and

$P_{c\,(B;f)\,t}$ = specific core loss value with flux perpendicular to the rolling direction, W/lb [W/kg].

NOTE 5—This definition of anisotropy normally applies to electrical steels with measurements made in an Epstein frame at a flux density of 15 kG [1.5 T] and a frequency of 60 Hz (see Test Method A343).

anisotropy of permeability—the ratio of relative peak permeability measured with flux parallel to the rolling direction to the relative peak permeability measured with flux perpendicular to the rolling direction.

$$anisotropy\ of\ permeability = \frac{\mu_{prl}}{\mu_{prt}}$$

where:

μ_{prl} = relative peak permeability value with flux parallel to the rolling direction, and

μ_{prt} = relative peak permeability value with flux perpendicular to the rolling direction.

NOTE 6—This definition of anisotropy normally applies to electrical steels with measurements made in an Epstein frame at a flux density of 15 kG [1.5 T] and a frequency of 60 Hz (see Test Method A343).

antiferromagnetic material—a feebly magnetic material in which almost equal magnetic moments are lined up antiparallel to each other. Its susceptibility increases as the temperature is raised until a critical (Neél) temperature is reached; above this temperature the material becomes paramagnetic.

apparent power, P_a—the product (volt-amperes) of the rms exciting current and the applied rms *terminal* voltage in an *electric* circuit containing inductive impedance. The components of this impedance as a result of the winding will be linear, while the components as a result of the magnetic core will be nonlinear. The unit of apparent power is the volt-ampere, VA.

apparent power, specific, $P_{a(B;f)}$—the value of the apparent power divided by the active mass of the specimen, that is, volt-amperes per unit mass. The values of voltage and current are those developed at a maximum value of cyclically varying induction B and specified frequency f.

area, A—the geometric cross-sectional area of a magnetic path which is perpendicular to the direction of the induction.

Bloch wall—a domain wall in which the magnetic moment at any point is substantially parallel to the wall surface. See also **domain wall.**

Bohr magneton—a constant that is equal to the magnetic moment of an electron because of its spin. The value of the constant is ($9\ 274\ 078 \times 10^{-21}$ erg/gauss or $9\ 274\ 078 \times 10^{-24}$ J/T).

cgs-emu system of units—the system for measuring physical quantities in which the base units are the centimetre, gram, and second, and the numerical value of the magnetic constant, Γ_m, is unity.

coercive field strength, H_c—the (dc) magnetic field strength required to restore the magnetic induction to zero after the material has been symmetrically cyclically magnetized.

coercive field strength, intrinsic, H_{ci}—the (dc) magnetic field strength required to restore the instrinsic magnetic induction to zero after the material has been symmetrically cyclically magnetized.

coercivity, H_{cs}—the maximum value of coercive field strength that can be attained when the magnetic material is symmetrically cyclically magnetized to saturation induction, B_S.

core, laminated—a magnetic component constructed by stacking suitably thin pieces of magnetic material which are stamped, sheared, or milled from sheet or strip material. Individual pieces usually have an insulating surface coating to minimize eddy current losses in the assembled core.

core, mated—two or more magnetic core segments assembled with the magnetic flux path perpendicular to the mating surface.

core, powder (dust)—a magnetic core comprised of small particles of electrically insulated metallic ferromagnetic material. These cores are characterized by low hysteresis and eddy current losses.

core, tape-wound—a magnetic component constructed by the spiral winding of strip material onto a suitable mandrel. The strip material usually has an insulating surface coating which reduces interlaminar eddy current losses in the finished core.

core loss, ac eddy current, incremental, $P_{\Delta e}$—the power loss caused by eddy currents in a magnetic material that is cyclically magnetized.

core loss, ac eddy current, normal, P_e—the power losses as a result of eddy currents in a magnetic material that is symetrically cyclically magnetized.

NOTE 7—The voltage is generally assumed to be across the parallel combination of core inductance, L_1, and core resistance, R_1.

core loss, ac, incremental, $P_{c\Delta}$—the core loss in a magnetic material when the material is subjected simultaneously to a dc biasing magnetizing force and an alternating magnetizing force.

core loss, residual, P_r—the portion of the core loss power, P_c, which is not attributed to hysteresis or eddy current losses from classical assumptions.

core loss, ac, specific, $P_{c(B;f)}$—the active power (watts) expended per unit mass of magnetic material in which there is a cyclically varying induction of a specified maximum value, B, at a specified frequency, f.

core loss, ac, (total), P_c—the active power (watts) expended in a magnetic circuit in which there is a cyclically alternating induction.

NOTE 8—Measurements of core loss are normally made with sinusoidally alternating induction, or the results are corrected for deviations from the sinusoidal condition.

core loss density—the active power (watts) expended in a magnetic core in which there is a cyclically varying induction of a specified maximum value, B, at a specified frequency, f, divided by the effective volume of the core.

NOTE 9—This parameter is normally used only for non-laminated cores such as ferrite and powdered cores.

core plate—a generic term for any insulating material, formed metallurigically or applied externally as a thin surface coating, on sheet or strip stock used in the construction of laminated and tape wound cores.

coupling coefficient, k'—the ratio of the mutual inductance between two windings and the geometric mean of the individual self-inductances of the windings.

crest factor, *cf*—the ratio of the maximum value of a periodically alternating quantity to its rms value.

NOTE 10—For a sinusoidal variation the crest factor is $\sqrt{2}$.

Curie temperature, T_c—the temperature above which a ferromagnetic material becomes paramagnetic.

current, ac core loss, I_c—the rms value of the in-phase component (with respect to the induced voltage) of the exciting current supplied to a coil which is linked with a ferromagnetic core.

current, ac exciting, *I*—the rms value of the total current supplied to a coil that is linked with a ferromagnetic core.

NOTE 11—Exciting current is measured under the condition that any other coil linking the same core carries no current.

current, ac, magnetizing, I_m—the rms value of the magnetizing component (lagging with respect to applied voltage) of the exciting current supplied to a coil that is linked with a ferromagnetic core.

current, dc, I_{dc}—a steady-state dc current. A dc current flowing in an inductor winding will produce a unidirectional magnetic field in the magnetic material.

customary units—a set of industry-unique units from the cgs-emu system of units and U.S. inch-pound systems and units derived from the two systems.

NOTE 12—Examples of customary units used in ASTM A06 standards include:

Quantity Name	Quantity Symbol	Unit Name	Unit Symbol
Magnetic field strength	*H*	oersted	Oe
Magnetic induction (magnetic flux density)	*B*	gauss	G
Specific core loss	$P_c(\beta;f)$	watt/pound	W/lb

cyclically magnetized condition, *CM*—a magnetic material is in a cyclically magnetized condition when, after having been subjected to a sufficient number of identical cycles of magnetizing field, it follows identical hysteresis or flux-current loops on successive cycles which are not symmetrical with respect to the origin of the axes.

demagnetization curve—the portion of a flux versus dc current plot (dc hysteresis loop) that lies in the second or fourth quadrant, that is, between the residual induction point, B_r, and the coercive force point, H_c. Points on this curve are designated by the coordinates, B_d and H_d.

demagnetizing coefficient, D_B—is defined by the equation:

$$D_B = [\Gamma_m(H_a - H)]/B_i$$

where:

H_a = applied magnetic field strength,
H = magnetic field strength actually existing in the magnetic material,
B_i = intrinsic induction, and
Γ_m = 1 in the cgs system and $4\pi \times 10^{-7}$, henry/metre in the SI system.

NOTE 13—For a closed, uniform magnetic circuit, the demagnetizing coefficient is zero.

demagnetizing factor, N_D—defined as 4π times the demagnetizing coefficient, D_B.

demagnetizing field strength, H_d—a magnetic field strength applied in such a direction as to reduce the induction in a magnetized body. See **demagnetization curve.**

density, δ—the ratio of mass to volume of a material. In the cgs-emu system of units, g/cm^3. In SI units, kg/m^3.

diamagnetic material—a material whose relative permeability is less than unity.

NOTE 14—The intrinsic induction, B_i, is oppositely directly to the applied magnetizing force *H*.

dissipation factor, magnetic, D_m—the tangent of the hysteretic angle that is equal to the ratio of the core loss current, I_c, to the magnetizing current, I_m. Thus:

$$D_m = \tan\beta = \cot\gamma = I_c/I_m = \omega L_1/R_1 = I/Q_m$$

NOTE 15—This dissipation factor is also given by the ratio of the energy dissipated in the core per cycle of a periodic *SCM* excitation (hysteresis and eddy current heat loss) to 2π times the maximum energy stored in the core.

distortion, harmonic—the departure of any periodically varying waveform from a pure sinusoidal waveform.

NOTE 16—The distorted waveform that is symmetrical about the zero amplitude axis and is most frequently encountered in magnetic testing contains only the odd harmonic components, that is fundamental, 3rd harmonic, 5th harmonic, and so forth. Nonsymmetrical distorted waveforms must contain some even harmonic components, in addition to the fundamental and, perhaps, some odd harmonic components.

distortion factor, *df*—a numerical measure of the distortion in any ac nonsinusoidal waveform. For example, if by Fourier analysis or direct measurement E_1, E_2, E_3, and so forth are the effective values of the pure sinusoidal harmonic components of a distorted voltage waveform, then the distortion factor is the ratio of the root mean square of the second and all higher harmonic components to the fundamental component.

$$df = [E_2^2 + E_3^2 + E_4^2 + \cdots]^{1/2} E_1$$

NOTE 17—There are no dc components (E_0) in the distortion factor.

domains, ferromagnetic—magnetized regions, either macroscopic or microscopic in size, within ferromagnetic materials. Each domain, in itself, is magnetized to intrinsic saturation at all times, and this saturation induction is unidirectional within the domain.

domain wall—a boundary region between two adjacent domains within which the orientation of the magnetic moment of one domain changes into a different orientation of the magnetic moment in the other domain.

eddy current—an electric current developed in a material as a result of induced voltages developed in the material.

effective circuit permeability, μ_{eff}—when a magnetic circuit consists of two or more components, each individually homogeneous throughout but having different permeability values, the effective (overall) permeability of the circuit is that value computed in terms of the total magnetomotive force, the total resulting flux, and the geometry of the circuit.

electrical steel—a term used commercially to designate strip or sheet used in electrical applications and historically has referred to flat-rolled, low-carbon steels or alloyed steels with silicon or aluminum, or both. Common types of electrical steels used in the industry are grain-oriented electrical steel, nonoriented electrical steel, and magnetic lamination steel.

electrical steel, grain oriented—a flat-rolled silicon-iron alloy usually containing approximately 3 % silicon, having enhanced magnetic properties in the direction of rolling and normally used in transformer cores.

electrical steel, nonoriented—a flat-rolled silicon-iron or silicon-aluminum-iron alloy containing 0.0 to 3.5 % silicon and 0.0 to 1.0 % aluminum and having similar core loss in all directions.

emu—the notation emu is an indicator of electromagnetic units. When used in conjunction with magnetic moment, m, it denotes units of ergs per oersted, erg/Oe. A moment of 1 erg/Oe is produced by a current of 10 amperes (1 abampere) flowing in a loop of area 1 cm^2. The work done to rotate a moment of 1 erg/Oe from parallel to perpendicular in a uniform field of 1 Oe is 1 erg. The conversion to the SI units of magnetic moment J/T (joule/tesla) or A m^2 is given by

$$\frac{\text{erg/Oe (cgs}-\text{emu)}}{\text{J/T (SI)}} \equiv \frac{10 \text{ amperes cm}^2 \text{ (cgs}-\text{emu)}}{\text{A m}^2 \text{ (SI)}} = 10^{-3} \quad (1)$$

Magnetization, M, the magnetic moment per unit volume, has units erg/(Oe-cm^3), often expresssed as emu/cm^3.

energy product, B_dH_d—the product of the coordinate values of any point on a demagnetization curve.

energy-product curve, magnetic—the curve obtained by plotting the product of the corresponding coordinates, B_d and H_d, of points on the demagnetization curve as abscissa against the induction, B_d, as ordinates.

NOTE 18—The maximum value of the energy product, $(B_dH_d)_m$, corresponds to the maximum value of the external energy.

NOTE 19—The demagnetization curve is plotted to the left of the vertical axis and usually the energy-product curve to the right.

energy product, maximum $(B_dH_d)_m$—for a given demagnetization curve, the maximum value of the energy product.

equipment test level accuracy—(*1*) For a single test equipment, using a large group of test specimens, the average percentage of test deviation from the correct average value.

(*2*) The average percentage deviation from the average value obtained from similar tests, on the same test specimen or specimens, when measured with a number of other test equipments that have previously been proven to have both suitable reproducibility of measurement and test level, and whose calibrations and quality have general acceptance for standardization purposes and where better equipment for establishing the absolute accuracy of test is not available.

exciting current, ac, I—See **current, ac exciting.**

exciting power, rms, P_z—the product of the ac rms exciting current and the rms voltage induced in the exciting (primary) winding on a magnetic core.

NOTE 20—This is the apparent volt-amperes required for the excitation of the magnetic core only. When the core has a secondary winding, the induced primary voltage is obtained from the measured open-circuit secondary voltage multiplied by the appropriate turns ratio.

exciting power, specific, $P_{z(B;f)}$—the value of the ac rms exciting power divided by the active mass of the specimen (volt-amperes/unit mass) taken at a specified maximum value of cyclically varying induction B and at a specified frequency f.

exciting voltage, E—the ac rms voltage across a winding linking the flux of a magnetic core. The voltage across the winding equals that across the assumed parallel combination of core inductance L_1, and core resistance, R_1.

feebly magnetic material—a material generally classified as "nonmagnetic," whose maximum normal permeability is less than 4.

ferrimagnetic material—a material whose atomic magnetic moments are both ordered and anti-parallel but being unequal in magnitude produce a net magnetization in one direction.

ferrite—a term referring to magnetic oxides in general, and especially to material having the formula M O Fe_2 O_3, where M is a divalent metal ion or a combination of such ions. Certain ferrites, magnetically "soft" in character, are useful for core applications at radio and higher frequencies because of their advantageous magnetic properties and high volume resistivity. Other ferrites, magnetically "hard" in character, have desirable permanent magnet properties.

ferromagnetic material—a material whose magnetic moments are ordered and parallel producing magnetization in one direction.

figure of merit, magnetic, μ'**/cot** γ—the ratio of the real part of the complex relative permeability to the dissipation factor of a ferromagnetic material.

NOTE 21—The figure of merit index of the magnetic efficiency of the core in various ac electromagnetic devices.

flux-current loop, incremental (biased)—the curve developed by plotting magnetic induction, B, versus magnetic field strength, H, when the magnetic material is cyclically magnetized while under dc bias condition. This loop will not be symmetrical about the B and H axes.

flux-current loop, normal—the curve developed by plotting magnetic induction, B, versus magnetic field strength, H, when the magnetic material is symmetrically cyclically magnetized.

NOTE 22—The area of the loop is proportional to the sum of the static hysteresis loss and all dynamic losses.

flux linkage, $\mathcal{L}$—the sum of all flux lines in a coil.

$$\mathcal{L} = \phi_1 + \phi_2 + \phi_3 + \cdots \phi_N$$

where:

ϕ_1 = flux linking turn 1;
ϕ_2 = flux linking turn 2, and so forth; and
ϕ_N = flux linking the Nth turn.

NOTE 23—When the coupling coefficient, k', is less than unity, the flux linkage equals the product of the average flux linking the turns and the total number of turns. When the coupling coefficient is equal to unity, the flux linkage equals the product of the total flux linking the coil and the total number of turns.

flux linkage, mutual, $\mathscr{L}_m$—the flux linkage existing between two windings on a magnetic circuit. Mutual linkage is maximum when the coupling coefficient is unity.

flux path length, ℓ—the distance along a flux loop.

flux path length, effective, ℓ_1—the calculated length of the flux paths in a magnetic core, which is used in the calculations of certain magnetic parameters.

flux volts, E_f—the voltage induced in a winding of a magnetic component when the magnetic material is subjected to repeated magnetization under *SCM* or *CM* conditions.

$$E_f = 4.443\ B_{max} A' N f \times 10^{-8}\ \text{V}\ (SCM\ \text{excitation})$$
$$E_f = 2.221\ \Delta\ B A'\ N f \times\ 10^{8}\ \text{V}\ (CM\ \text{excitation})$$
$$E_f = 1.1107\ E_{avg}$$

which
A' = solid cross-sectional area of the core in cm^2,
N = number of winding turns, and
f = the frequency in hertz.

form factor, *ff*—the ratio of the rms value of a periodically alternating quantity to its average absolute value.

NOTE 24—For a sinusoidal variation, the form factor is:

$$\pi / 2\sqrt{2} = 1.1107$$

frequency, angular, ω—the number of radians per second traversed by a rotating vector that represents any periodically varying quantity.

NOTE 25—Angular frequency, ω, is equal to 2π times the cyclic frequency, *f*.

frequency, cyclic, *f*—the number of hertz (cycles/second) of a periodic quantity.

gap length, ℓ_g—the distance that the flux transverses in the central region of a gap in a core having an "air" (nonmagnetic) gap in the flux path may be considered unity in the gap.

gauss (plural gausses), G—the unit of magnetic induction in the cgs-emu system of units. The gauss is equal to 1 maxwell per square centimetre of 10^{-4} tesla. See **magnetic induction (flux density).**

gilbert, Gb—the unit of magnetomotive force in the cgs-emu system of units. The gilbert is a magnetomotive force of 4π/10 ampere-turns. See **magnetomotive force.**

gyromagnetic ratio, proton, γ_p—the ratio of the magnetic moment of a hydrogen nucleus to its angular momentum.

NOTE 26—The gyromagnetic ratio is used to calculate the magnetic field from a measured resonance frequency when using the nuclear magnetic resonance technique.
The relationship is:

$$B = (2\pi f/\gamma_p)\ \text{gausses} = (2\pi f/\gamma_p) \times 10^{-4}\ \text{teslas}$$

where:
f = resonance frequency in cycles per second (hertz) and
γ_p = gyromagnetic ratio (the accepted value at present for water is $2.675\,12 \times 10^4\ \text{gauss}^{-1}\ \text{s}^{-1}$).

henry (plural henries), H—the unit of self- or mutual inductance. The henry is the inductance of a circuit in which a voltage of 1 V is induced by a uniform rate of change 1 A/s in the circuit. Alternatively, it is the inductance of a circuit in which an electric current of 1 A/s produces a flux linkage of one weber turn (Wb turn) or 10^8 maxwell-turns. See **inductance, mutual, and inductance, self.**

hertz, Hz—the unit of cyclic frequency, *f*.

hysteresis loop, biased—an incremental hysteresis loop that lies entirely in any one quadrant.

NOTE 27—In this case, both of the limiting values of *H* and *B* are in the same direction.

hysteresis loop, incremental—the hysteresis loop, nonsymmetrical with respect to the *B* and *H* axes, exhibited by a ferromagnetic material in a *CM* condition.

NOTE 28—In this case, both of the limiting values *H* may have opposite polarity, but definitely have different absolute values of H_m. An incremental loop may be initiated at either some point on a normal hysteresis loop or at some point on the normal induction curve of the specimen.

hysteresis loop, intrinsic—a hysteresis loop obtained with a ferromagnetic material by plotting (usually to rectangular coordinates) corresponding dc values of intrinsic induction, B_i, for ordinates and magnetic field strength *H* for abscissae.

hysteresis loop, normal—a closed curve obtained with a ferromagnetic material by plotting (usually to rectangular coordinates) corresponding dc values of magnetic induction (*B*) for ordinates and magnetic field strength (*H*) for abscissa when the material is passing through a complete cycle between equal definite limits of either magnetic field strength, $\pm H_m$, or magnetic induction, $\pm B_m$. In general, the normal hysteresis loop has mirror symmetry with respect to the origin of the *B* and *H* axes, but this may not be true for special materials.

hysteresis loop loss, W_h—the power expended in a single slow excursion around a normal hysteresis loop. The energy is the integrated area enclosed by the loop measured in gauss-oersteds. Using the cgs-emu system of units:

$$W_h = (\int H dB / 4\pi)\ \text{ergs}$$

where the integrated area enclosed by the loop is measured in gauss-oersteds.

hysteresis loss, incremental, $P_{\Delta h}$—the power (watts) as a result of hysteresis expended in a ferromagnetic material while being driven through an incremental flux-current loop by a *CM*-type of excitation.

hysteresis loss, normal, P_h—(*1*) the power expended in a ferromagnetic material, as a result of hysteresis, when the material is subjected to a *SCM* excitation.

(*2*) The energy loss/cycle in a magnetic material as a result of magnetic hysteresis when the induction is cyclic (but not necessarily periodic).

hysteresis loss, rotational—the hysteresis loss that occurs in a