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

This standard is issued under the fixed designation A340; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## INTRODUCTION

In preparing this terminology standard, 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 and clarity, but it is believed that none of the definitions will prove to be misleading.

It is the intent of this terminology standard to be consistent in the use of symbols and units with those found in IEC 60050-221:1990 International Electrotechnical Vocabulary Chapter 221: Magnetic materials and components. Although Committee A06 has chosen to make SI units normative, the extensive technical and commercial literature using the older Gaussian units requires that many definitions contain discussion about and use of both unit systems. This is not an endorsement of the older unit system and users of this terminology are encouraged to use SI units where possible.

## 1. Referenced Documents

1.1 *ASTM Standards:*[2]

A343/A343M Test Method for Alternating-Current Magnetic Properties of Materials at Power Frequencies Using Wattmeter-Ammeter-Voltmeter Method and 25-cm Epstein Test Frame

A772/A772M Test Method for AC Magnetic Permeability of Materials Using Sinusoidal Current

## 2. Terminology

[1] This terminology is under the jurisdiction of ASTM Committee A06 on Magnetic Properties and is the direct responsibility of Subcommittee A06.92 on Terminology and Definitions.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

### Part 1—Symbols Used in Magnetic Testing

| Symbol | Term |
|---|---|
| $a$ | cross-sectional area of $B$ coil |
| $A$ | cross-sectional area of specimen |
| $A'$ | solid area |
| $B$ | magnetic flux density; magnetic induction |
| $\Delta B$ | excursion range of induction |
| $B_b$ | biased flux density |
| $B_d$ | demagnetization flux density |
| $B_dH_d$ | energy product |
| $(BH)_{max}$ | maximum energy product |
| $B_\Delta$ | incremental flux density |
| $B_i$ | intrinsic flux density |
| $B_m$ | maximum value of magnetic flux density in a static hysteresis loop |
| $B_{\max}$ | maximum value of magnetic flux density in a dynamic hysteresis loop |
| $B_r$ | residual flux density |
| $B_s$ | saturation flux density |
| $cf$ | crest factor |
| $CM$ | cyclically magnetized condition |
| $d$ | lamination thickness |
| $df$ | 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 |
| $\Delta H$ | excursion range of magnetic field strength |
| $H_b$ | biasing magnetic field strength |
| $H_{cB}$ | coercive field strength |
| $H_{cJ}$ | intrinsic coercive field strength |
| $H_d$ | demagnetizing field strength |

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| $H_{\Delta}$ | incremental 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 hysteresis 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 (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 |
| $J_r$ | residual magnetic polarization |
| $J_s$ | saturation magnetic polarization |
| $k'$ | coupling coefficient |
| $\ell$ | flux path length |
| $\ell_1$ | effective flux path length |
| $\ell_g$ | gap length |
| $\mathscr{L}$ (also $\varphi N$) | flux linkage |
| $\mathscr{L}_m$ | mutual flux linkage |
| $L$ | self inductance |
| $L_1$ | core inductance |
| $L_{\Delta}$ | incremental inductance |
| $L_i$ | intrinsic inductance |
| $L_m$ | mutual inductance |
| $L_0$ | initial inductance |
| $L_s$ | series inductance |
| $L_w$ | winding inductance |
| $\mathscr{m}$ | magnetic moment |
| $M$ | magnetization |
| $M_r$ | residual magnetization |
| $M_s$ | saturation magnetization |
| $m$ | total mass of a specimen |
| $m_1$ | active mass of a specimen |
| $N$ | demagnetizing factor |
| $N_1$ | turns in a primary winding |
| $N_2$ | turns in a secondary winding |
| $p$ | magnetic pole strength |
| $\mathscr{P}$ | permeance |
| $P$ | active (real) power |
| $P_a$ | apparent power |
| $P_{a\ (B;f)}$ | specific apparent power |
| $P_c$ | core loss |
| $P_{c\ (B;f)}$ | specific core loss |
| $P_e$ | eddy current loss |
| $P_h$ | normal hysteresis core loss |
| $P_q$ | reactive (quadrature) power |
| $P_r$ | residual core loss |

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| $P_w$ | winding loss (copper loss) |
| $P_z$ | exciting power |
| $P_{z\ (B;f)}$ | specific exciting power |
| $Q_m$ | magnetic storage factor |
| $\mathscr{R}$ | 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 energy loss |
| $\bar{\alpha}$ | linear expansion, coefficient (average) |
| $\Delta\chi$ | incremental tolerance |
| $\beta$ | hysteretic angle |
| $\gamma$ | loss angle |
| $\cos\gamma$ | magnetic power factor |
| $\gamma_p$ | proton gyromagnetic ratio |
| $\mu_0$ | magnetic constant |
| $\delta$ | density |
| $\kappa$ | susceptibility |
| $\mu$ | absolute permeability |
| $\mu_e$ | effective circuit permeability |
| *ac Permeabilities:* | |
| $\mu_{a,eff}$ | rms amplitude permeability |
| $\mu_a$ | amplitude permeability |
| $\mu_L$ | inductance permeability |
| $\mu_{\Delta}L$ | incremental inductance permeability |
| $\mu_p$ | peak permeability |
| $\mu_{\Delta p}$ | incremental peak permeability |
| $\mu_i$ | instantaneous permeability |
| $\mu_z$ | impedance permeability |
| $\mu_{\Delta z}$ | incremental impedance permeability |
| *dc Permeabilities:* | |
| $\mu$ | normal permeability |
| $\mu_d$ | differential permeability |
| $\mu_{\Delta}$ | incremental permeability |
| $\mu_{\Delta i}$ | incremental intrinsic permeability |
| $\mu_m$ | maximum permeability |
| $\mu_i$ | initial permeability |
| $\mu_r$ | relative permeability |
| $\mu_{rev}$ | reversible permeability |
| $\mu'/\cot\gamma$ | figure of merit |
| $\nu$ | reluctivity |
| $\pi$ | the numeric 3.1416 |
| $\rho$ | resistivity |
| $\varphi$ | magnetic flux |
| $\varphi N$ | flux linkage (see $\mathscr{L}$) |
| $\chi$ | mass susceptibility |
| $\chi_0$ | initial susceptibility |
| $\omega$ | angular frequency in radians per second |

## Part 2—Definition of Terms Used in Magnetic Testing

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

DISCUSSION—The aging treatments usually specified for iron and steel are:

(*a*) 100 h at 150°C or
(*b*) 600 h at 100°C.

**aging, magnetic—**the time dependent change in magnetic properties; such changes can be due to either intrinsic or extrinsic factors, are not a consequence of improper use of the material and are usually detrimental to magnetic performance; in some instances, it may be possible to reverse the effect of magnetic aging via heat treatment or some other process, but typically the benefits are short-lived, and aging will occur again.

DISCUSSION—Two types of magnetic aging can be defined:

(*a*) Intrinsic magnetic aging due to the material as manufactured not being in its thermodynamically stable state so that further microstructural changes occur during service. Such aging is strongly dependent on temperature. The classic example is the aging of iron and electrical steels due to the precipitation of nitrides and carbides. Other examples would include amorphous, nanocrystalline materials and thin films where residual stresses introduced during manufacturing are slowly relieved during service. Ferrofluids show magnetic aging effects due to time dependent degradation of surfactants which results in a settling of the colloidal particles.

(*b*) Extrinsic or environmental magnetic aging due to changes in the magnetic domain structure or microstructure caused by external factors such as mechanical vibration, corrosion, irradiation, service temperature fluctuations, and external magnetic fields. Unlike intrinsic