Glossary of Magnetic Terms

AlNiCo
Permanent magnets based upon alloys containing aluminum, nickel, cobalt, iron + additions. They are very stable materials and are not sensitive to moderate temperature changes or mildly corrosive environments.

Anisotropic
When magnetic properties are intrinsically stronger in a preferred direction. Higher flux levels are available in the direction of magnetic orientation.

A.S.T.M.
American Society for the Testing of Materials.

Bh_{max}
Maximum energy product of a magnet. A descriptive term to quantify the potential power of a magnet material (kJ/m^3 equals 0.1256 MGO_e).

C.G.S.
The system of units based on centimeter, gram and second.

Coercive Force, Intrinsic (H_{cJ})
The magnetizing field required to reduce the intrinsic magnetization J to zero.
(1 A/m = 0.01256 Oe)

Coercive Force, Normal (H_{cB})
The magnetizing field required to reduce the normal magnetization B to zero.
(1 A/m = 0.01256 Oe)

Curie Temperature (T_c)
The temperature above which a magnetic material ceases to have any ferromagnetic properties. In practice this is much higher than the useful maximum operating temperature of a permanent magnet.

De-magnetisation
Process to reduce the flux within a permanent magnet to either a set limit or to zero. Can occur through exposure to high DC or AC magnetic fields, or by heating to temperatures near to or above the Curie temperature.

De-magnetisation Curve
The curve which describes the demagnetization of a permanent magnet in the second quadrant of its hysteresis loop after first being magnetized. Both the intrinsic and normal curves may be shown. Among other important data, the curves yield B_r, BH_{max}, H_{cJ} and H_{cB}.

Diamagnetic Materials
Materials which have a permeability which is very slightly negative and opposes the application of the magnetic field. Examples are copper, silver and gold.

Dimensional Ratio
The ratio of the mean length of the magnet to its diameter. For a magnet in an open circuit the dimensional ratio can be related to the B/H ratio.
Electro-Motive Force (e.m.f.)
The term used to describe the quantity of work per unit charge which is quantified as the volt (V).

Ferrimagnetic Materials
An important class of magnetic materials. They behave like feral magnets in that they display high permeability and hysteresis. Typically they have lower saturation magnetization and are produced in the form of magnetic oxides.

Ferrite Material
Ferrite magnets are ferrimagnetic and may be either “hard” (permanent) or “soft”. In the case of permanent magnets they are based on a mixture of barium, strontium and iron oxide. They can be produced using a sintering or plastic bonding process. They may be isotropic or anisotropic

Ferromagnetic Materials
These are the only materials which have a high spontaneous magnetization. This is due to a special combination of electron spins and separation of atoms. The permeability may be more than 1 million times that of the dire and paramagnetic materials. Iron, nickel and cobalt other well-known metals which have high permeability at room temperature. Some of the rare earth (lanthanide) metals are ferromagnetic - but only at low temperatures. An important sub-class of ferromagnets are the ferrimagnets. These are materials which show ferromagnetic type behavior but are typified by having lower saturation.

Fluxmeter
An instrument for measuring the total magnetic flux produced in a specific area. Most often a heavily damped electronic voltage integrator.

Gauss
The C.G.S. unit of magnetic flux density.

Gaussmeter

An instrument for measuring instantaneous values of magnetic flux density at a point in space. They usually incorporate all affect probes.

Henry (H)
The S. I. unit of mutual inductance derived from Weber per ampere (Wb/A).

Hysteresis Loop
A closed curve which describes the relationship between magnetic flux density B and magnetizing field H for a ferromagnetic material. The area contained within the loop is related to specific energy and is an important magnetic parameter.

I.E.C.
International Electrotechnical Commission. A body which creates world standards for magnetic materials and test methods.

Irreversible Losses
The loss in the flux density when a magnet is partially the magnetized by being at a temperature and operating point to severe to sustain linear behavior. Re-magnetization is the only way to recover these losses.

Isotropic
A non-oriented magnetic material which has similar physical and magnetic properties in all directions.

Leakage Factor
Accounts for the flux leakage from the magnetic circuit. Is the ratio between the maximum magnetic flux in the circuit and the average useful flux in the air gap and is usually a value between 2 and 20.

Leakage Flux
The flux whose path is outside the intended magnetic circuit.

Load Line
A line drawn from the origin of a hysteresis loop to the operating point of a magnetized magnet or system. In dynamic magnetic circuits this is a variable.

Magnetic field strength (H)
The m.m.f. per unit length. The S. I. unit of magnetic strength is the ampere per meter (A/m).

Magnetic flux (Φ)
The S. I. unit of magnetic flux is the weber. (1 weber = 108 maxwell (C.G.S.)). Is the amount of magnetic flux which when reduced steadily to zero in one second produces an e.m.f. of 1 volt in a one turn coil.

Magnetic Flux Density (B)
The magnetic flux passing through a unit area. (Unit: tesla = weber/m^2).

Magnetic Induction (see Magnetic Flux Density)

Magnetic Materials
All materials are by definition “magnetic” and they are classified by their response to the application of a magnetic field (*permeability* or *susceptibility*). Essentially, the permeability or susceptibility depends upon the electron spin around the nuclei of atoms and their inter-atomic separation.

Magnetic Materials in Industry
Depending upon which ally or processing route is followed, ferromagnetic materials can be produced as permanent magnets or soft magnetic materials. For example alloys of iron, aluminum, cobalt and nickel are the basis for the “AlNiCo” family of permanent magnets and alloys based upon iron and the rare earth metal, neodymium, are the basis of the so-called “NdFeB” magnets. Alloys of iron with nickel, silicon, cobalt or chromium form the basis for the world-wide soft magnets industry for applications which require properties beyond those of iron or low carbon steels.
For the ferrimagnetic class of magnets, examples are barium and strontium ferrite's used as permanent magnets manganese or nickel ferrite used in soft magnetic cores and y-ferric oxide white in magnetic recording.

Magnetizing
The process to charge a permanent magnet before it can be useful. The magnetizing field can be applied by a permanent magnet, and electromagnet or a post solenoid.

Magnetomotive force (m.m.f.)
The total magnetic potential difference across a given length expressed as Ampere (A) in S. I. units

Maximum Permeability (μ_{max})
For a soft magnetic material it is the peak value obtained for B/H. It is a widely used control parameter when specifying such material.

Maxwell (M)
The C.G.S. unit of magnetic flux. (1 maxwell = 10^{-8} weber)

Neodymium Iron Boron (NdFeB)
A general term to describe the family of magnets based on the tetragonal $Nd_2Fe_{14}B$ compound. Magnets may be fully dense or polymer bonded. They have the highest room temperature energy product.

Oersted (Oe)
The C.G.S. unit of magnetic field strength. (1 Oe = 1000/4π ≡ 79.6 A/m).

Operating Point
The operating point is the crossing between load line and the de-magnetization curve.

Orientation
The preferred direction of magnetization of a permanent magnet. The material may be physically aligned through pressing or heat treatment during manufacture.

Paramagnetic Materials
Materials which have a slight positive permeability. Examples are aluminum, platinum and manganese.

Permanent Magnetic Material
A material which may be relatively easy or hard to magnetize but is very difficult to de-magnetize. Permanent magnets are compounds which possess a strong resistance to rotation of the magnetization away from the preferred direction. This may be achieved by crystal anisotropy or by inclusion of the main wall pinning mechanisms.

Permeability (μ)
The general term to express the relationship between magnetic flux density and applied magnetic field strength, i.e. the instantaneous value of B/H.

Permeability of free space (μ_o)
The defined constant for B/H in a vacuum equivalent to $4\pi \times 10^{-7}$ H/m.

Recoil Permeability (μ_{rec})
The slope of the recoil loop on the hysteresis curve for a permanent magnet material. For hard ferrite and a rare earth materials this value may be constant and close to unity. For alnico materials is likely to be between 1.8 and 6.0.

Reluctance
The resistance of the magnetic circuit to the passage of flux.

Reluctance loss factor
A constant for a given design usually between 1.1 to 1.5.

Remanence
The flux density (B_r or J_r) which remains in a magnetic material in a closed magnetic circuit after magnetization but with the field removed.

Remanent Flux Density
The flux density which remains in a magnetic material after magnetization and conditioning for final use.

Reversible Losses
The reversible loss in flux density of a magnet when it is subjected to higher temperatures. Related to the temperature coefficient.

Samarium Cobalt (SmCo)
Samarium Cobalt is the name given to families of materials based on the SmCo and Sm_2Co_{17} alloys. They are characterized by their high magnetic strength at elevated temperatures.

S.I.
The System International unit agreement based on the meter, kilogram andsecond.

Soft Magnetic Material
A term which describes a magnetic material which is both easy to magnetize and to demagnetize. The intrinsic structure of these materials is such that they are easy to magnetize in all directions.

Glossary of Magnetic Terms

Temperature coefficient
A value which describes the change in magnetic property with a change in temperature. Usually expressed as percentage change per unit of temperature.

e.g., for the temperature coefficient of a remanence

$$B_r\,(\%) = \frac{(B_{r(T1)} - B_{r(T2)})}{B_{r(T1)} \cdot (T_1 - T_2)} \times 100\% \,/\, {}^\circ C$$

A similar expression can be used for coercivity (H_{cB}, H_{cj}) or energy product (Bh_{max}).

Temperature coefficients are not linear but can be treated as such when operating temperatures are much lower than the Curie temperature.

Tesla (T)
The S.I. unit of magnetic flux density. (1 tesla = 10,000 gauss).

Weber (Wb)

The amount of flux which when gradually reduced to zero includes 1 volt in a single turn coil in one second. (1 weber = 10^8 maxwell).

DEFINITION	SYMBOL	S.I. UNITS*	G.G.S UNITS**	TO CONVERT FROM S.I.UNITS INTO C.G.S. UNITS, MULTIPLY BY
Magnetic Field	H	ampere per metre (A/m)	oersted, Oe	0.01256
	H	kA/m	oersted	12.56
Magnetic Flux Density	B	tesla (T)	gauss, G	10,000
	B	mT	gauss	10
Energy Product	B x H	kj/m³	M.gauss. oersted, MGOe	0.1256
Magnetic Flux	ϕ	weber (Wb)	maxwell	100,000,000
	ϕ	m(Wb)	maxwell	100,000`
	ϕ	u(Wb)	maxwell	100