Stratton Products Ltd.

# Common Magnetic Terms

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## Air gap

An 'air gap' is non-magnetic material, which is present between a magnet and an attracted object or between two magnets that are attracting each other.

An air gap is best described as a break in the magnetic circuit, which magnetism has to jump through to continue a circuit between north and south poles. The introduction of an air gap weakens the magnetic hold.

An air gap can be air itself or a solid non-ferrous material that does not conduct magnetism such as wood, plastic or aluminium. It could also be a thickness of paint or a surface that is very uneven. Refer to the 'Pull-gap' curve entry for a description of how pull strength decreases as the size of an air gap increases.

## Anisotropic

Material with a preferred direction of magnetisation that cannot normally be changed after the material has been manufactured. Anisotropic magnets have a considerably higher energy product when compared to the isotropic version of the same material.

## Axis

The direction through which a magnet is magnetised.

## (BH) max

Maximum energy product indicates the highest energy obtained from a given permanent magnet material when operating at the optimum working point. In most applications the strength of different materials is proportional to (BH) max. (KJ/m3 = 0.1256 MGOe).

## Coercive Force

The negative field required to reduce magnetic flux to zero after saturation. (1 A/m = 0.01256 Oe).

## Coercivity Hc

The capability of a magnet to resist demagnetising fields. This is characterised by coercive force.

## Curie Temperature

A temperature above which a magnet material ceases to have any ferromagnetic properties. This is much higher than the useful maximum operating temperature of a magnet.

## Demagnetisation

Demagnetisation occurs when a magnet loses its external magnetic field when in open circuit.

This can be through physical stress or corrosion, through heating the magnet beyond its maximum operating temperature or by exposing the material to a strong demagnetising magnetic field.

Generally, neodymium magnets cannot be re-magnetised once their magnetic properties have been lost.

## Demagnetisation Curve

The second quadrant of the hysteresis loop after first being magnetised. Most magnets operate in this quadrant and therefore the curve contains information on the main magnet properties of a magnet.



4, The Avenue, Stanton Fitzwarren,
Wiltshire, SN6 7SE, United Kingdom

Phone: +44 (0) 1793 763 112
Email: sales@strattonproducts.co.uk
Web site: www.strattonproducts.co.uk

## Density

Density is a measurement of a materials mass per unit of volume. All materials have different densities and a magnet's density can allow you to calculate its weight. The density values for the different types of magnetic material are as follows:

- Neodymium magnets have a density of up to 7.5g per cm3
- The density of alnico magnets vary depending on the grade from 6.9 to 7.3g per cm3
- The density of samarium cobalt magnets vary depending on the grade from 8.2 to 8.4g per cm3
- Ferrite magnets have a density of 5g per cm3
- Flexible magnets have a density of 3.5g per cm3

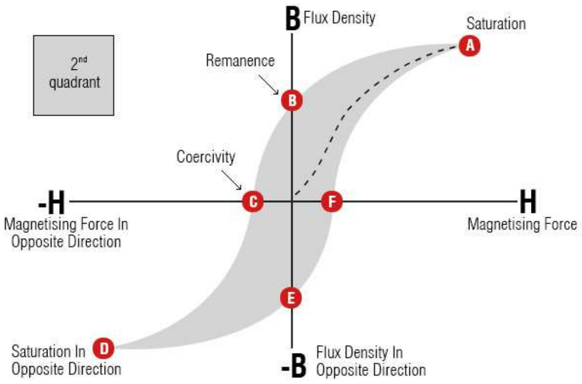
## Gauss

A unit of magnetic flux density. (10,000 gauss = 1 tesla).

## Hysteresis loop

A four quadrant graph, showing magnetising force relative to resultant magnetisation of a permanent magnet material as it is successively magnetised to its saturation point, then demagnetised, magnetised in the reverse polar direction and then finally re-magnetised.

When the cycles are complete, this four quadrant graph will be a closed loop which illustrates the magnetic characteristics of the magnetic material under test. Magnetically hard materials have a larger area inside the loop which denotes the level of magnetic energy. Magnetically soft materials lose magnetism when the magnetising field is removed and therefore these have very small areas inside the loop. The second quadrant within the four quadrants (+X and -Y) is the most important of the four curves and is known as the demagnetisation curve.




## Isotropic

Has no preferred direction of orientation and can therefore be magnetised in any direction.

## Maximum Operating Temperature (Tmax)

The maximum operating temperature is exactly as it sounds, it represents the maximum temperature that a particular grade of magnet will be able to function at, before it becomes permanently demagnetised.

All permanent magnets weaken in relation to their temperature coefficient, but as long as the maximum operating temperature is not exceeded, this is fully recoverable on cooling. If the maximum operating temperature is exceeded, then the losses will not be fully recovered on cooling. Repeatedly heating a magnet above its maximum operating temperature and cooling will significantly demagnetise the magnet.

Neodymium magnets operate best in cold temperatures down to approximately -130°C. Regular neodymium magnets will maintain their magnetism in operating temperatures up to 80°C whereas different variants of neodymium magnets can operate up to temperatures of 230°C.

## Maxwell

Maxwell is a measurement for magnetic flux on the CGS scale where 1 Maxwell is equal to 1 line of flux. The measurement is named after James Clerk Maxwell who was a Scottish theoretical physicist born in 1831. Maxwell's most high-profile achievement was formulating a set of equations that united electricity, magnets and optics into one consistent theory. Maxwell's achievements were widely acclaimed as the second great unification in physics after those realised by Isaac Newton.

## Mega Gauss Oersteds (MGOe)

The maximum energy product of B & H is the CGS measure of the maximum energy product of a magnet (BHmax), at the working point on a normal bHc curve. This is commonly used to designate varying grades of permanent magnet materials.

The five main types of magnet material have the following typical maximum energy products:

- Neodymium up to 52 MGOe
- Alnico up to 5.5 MGOe
- Ferrite up to 3.5 MGOe
- Samarium Cobalt up to 32 MGOe
- Flexible magnets up to 2 MGOe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## Northpole

The end of a magnet which points to the geographical north, its correct title should be "north seeking pole".

## Oersted

The Oersted (Oe) is a measure for magnetic field strength and is named after the Danish physicist and chemist Hans Christian Oersted. In 1820, Oersted discovered the magnetic effect of electric current, contributing significantly to the study of magnetism. The Oersted is closely related to the Gauss measurement for flux density and is used to measure external electromagnetic forces usually produced in magnetisers and demagnetisers.

## Orientation

A magnet's orientation refers to the physical location and direction of its magnetic poles, e.g. through length, thickness, diameter, axially, radially or diametrically.

## Permeability

Some materials, when placed inside a magnetic field, become magnetised themselves. The permeability of a magnetic substance represents the increase or decrease of the magnetic field inside the substance compared to the magnetising field that the substance is located within. Simply put, it is the ability for a material to acquire its own magnetism or for magnetism to flow through it.

Ferromagnetic metals have the greatest permeability of all substances and will become magnetised when exposed to a magnetic field. The rate of magnetic permeability will increase until the substance reaches a point of saturation. 'Soft' ferromagnetic materials are easily magnetised, but once the external field is removed they lose most of their magnetism. Conversely, 'hard' ferromagnetic materials are difficult to magnetised, but once they are, they will remain magnetised.

## Plating

Plating is another term for coating. Platings or coatings are applied to raw neodymium magnets to prevent corrosion and demagnetisation. The most common coating is a layer of nickel, followed by a later of copper and then another layer of nickel.

We can provide many different coatings and platings for bespoke applications, including:

- Rubber
- Nickel (Ni)
- Epoxy
- Zinc (Zn)
- Gold (Au)
- Tin (Sn)
- Titanium (Ti)
- Titanium Nitride (TiN)
- Parylene C
- Everlube
- Chrome
- Polytetrafluoroethylene (PTFE, also known as Teflon Ni-Cu-Ni plus Epoxy)
- Nickel-Copper-Nickel, plus Rubber
- Zinc, plus Rubber
- Nickel-Copper-Nickel, plus Parylene
- Nickel-Copper-Nickel, plus PTFE
- Tin, plus Parylene
- Zinc chromate
- Phosphate Passivation

## Pull-gap curve

A pull-gap curve plots the 'pulling power' of a magnet in direct contact with a thick and flat piece of steel and then though a steadily increasing range of air gaps. Pull follows an inverse square law relationship with distance.

High field gradient magnets have the highest clamping forces in direct contact with ferrous material (zero air gap), but the weakest pull through steadily increasing air gaps.

Low field gradient magnets have the lowest clamping forces in direct contact with ferrous material (zero air gap), but the highest pull through steadily increasing air gaps.

A high field gradient magnet's pull-gap curve and a low field gradient magnet's pull-gap curve will cross over if plotted on the same graph.

## Pull strength

The pull strength is the highest possible holding power of a magnet, measured in kilograms. It is the force required to prise a magnet away from a flat surface of steel when the magnet and metals have full and direct surface-to-surface contact. The grade of the metal, surface condition and angle of pull all have an impact on the pull strength.

## Remanence,Br

Magnetic polarisation of a magnet material in a closed circuit after saturation but with the external magnetising force removed. Remanence is measured in units of gauss or tesla, however this must not be confused with the open circuit or surface gauss/tesla readings from a magnet which are normally considerably lower than remanence.


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## Shear force / sliding resistance

As a rule of thumb it is five times easier to slide a magnet than to pull it vertically off the surface of a ferrous material.

When a magnet slides on steel, the coefficient of friction is approximately 0.2 and this is how the five times is derived.

Magnets attached to a vertical steel wall will slide down the wall when only 20% of the rated pull is experienced as a load. Rubber coated magnets have a much higher coefficient of friction and therefore will resist sliding at a far higher rate because of the friction caused by the coating.

If the vertical wall is made of thin sheet steel which cannot absorb all the magnetism generated by the magnet, then the holding force will be reduced further.

## Stacking

Stacking refers to the process of placing magnets together to increase the net pull-strength. When five magnets are stacked together to make one magnet which is five times thicker, then this magnet will be substantially more powerful because of the increase in its L/d ratio (length to diameter). Once the length of the magnet exceeds the diameter of the magnet, the magnet is working at an optimum level and further additions to magnetic length will provide only small increases in performance.

## Surface Field / surface gauss

The surface field strength is measured in Gauss and is the magnet's maximum field strength taken from the magnet's pole surface. Measurements are usually taken using a gauss meter.

## Temperature Coefficient of Br

Temperature coefficient is a factor that is used to calculate the decrease in magnetic flux corresponding to an increase in operating temperature. The loss in magnetic flux is recovered when the operating temperature is decreased, providing the maximum operating temperature is not exceeded. The temperature coefficient for magnetic materials are typically;

- Neodymium 0.11 % per degree C rise in temperature
- Alnico 0.02% per degree C rise in temperature
- Ferrite 0.2% per degree C rise in temperature
- Samarium cobalt 0.03 % per degree C rise in temperature
- Flexible magnets 0.2 % per degree C rise in temperature

## Tesla

Unit of magnetic flux density. (1 tesla = 10,000 gauss).

## Working Point

Point on a demagnetisation curve at which the magnet functions. This is governed by temperature, operating conditions and the geometry of the magnet.


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