Information about magnetic materials

Neodymium-Iron-Boron magnets (NdFeB)

Their energy density is about 30% higher than that of SAMARIUM-COBALT (SmCo) magnets, their specific weight is lower, and their mechanical resistance much better.

They are produced by compression and sintering of ingots. Magnet shapes are cut out of these ingots by means of diamond charged cutting-off wheels, thus ensuring that small cutting tolerances can be kept. Large scale manufacture also permits the production of simple geometrical shapes such as disks, rings, or square blocks, through compression in a mould. The magnetic characteristics, however, are reduced by 10 ...15%.

The coercitivity field density diminishes in case of rising temperature. Depending on materials used, irreversible losses are caused after the operating temperature has been reached. The magnetic values operate at a Tk of +/- 0.11% per 1°C. In case of a small surface / thickness relationship, such irreversible losses are already caused before the indicated working temperature has been reached.

Characteristics (typical) NdFeB

Specific weight:	7.5 g/cm³
Compression resistance:	300 N/mm²
Flexional resistance:	140 N/mm²
Specific resistance:	1.5 µΩm
Maximum working temperature: (depending on type)	80 ... 180 °C
Thermal conductivity of Br :	0.11 %/°C
Magnetization field strength H:	>2000 kA/m

Samarium-Cobalt Magnets(SmCo)

The development of permanent magnets of the AlNiCo group and the ferrites has reached such a degree of quality, so that no further, marked improvements of their magnetic characteristics can be expected.

Kinds of permanent magnets, which consist of so-called «rare types of earth» (Samarium, Cer, Lanthan, etc.) and cobalt, have recently been developed to provide sophisticated solutions for particularly demanding problems.

In comparison to the classical permanent magnet matters, SAMARIUM-COBALT magnets offer the high flux density of the AlNiCo magnets combined with a very high coercitivity field density. Due to this characteristic, they can be employed in demagnetising fields without loss of magnetic force. Their use as repelling, instead of attracting, permanent magnets is a typical example.

SAMARIUM-COBALT magnets are mechanically hard and brittle. They can only be processed with the help of diamond charged tools.

Metallurgical composition

SmCo5	~ 35% samarium, 65% cobalt
SmCo 2:17	25% samarium, 50% cobalt small percent- ages of zircon and copper, the remaining part is iron

Characteristics (typical) SmCo 2:17

Specific weight:	8.4 g/cm³
compression resistance:	300 N/mm²
Flexional resistance:	70 N/mm²
Vickers pyramid hardness:	5’000 N/mm²
Bulk modulus of elasticity:	155’000 N/mm²
Thermal expansion:	5.6 ppm/°C
Specific resistance:	0.6 µΩm
Thermal conductivity:	12 W/m°C
Maximum working temperature:	300 °C
Temperature coefficient of Br:	0.04 %/°C
Magnetization field strength H:	
SmCo5	>2500 kA/m
SmCo 2:17	>4000 kA/m
Magnetization angle error:	5°

With optimum dimensions configuration at 2° producible (after consultation)

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Ferrit Magnets (HF)

The main characteristic of FERRIT magnets is their high resistance against demagnetising influences. The density of power lines is smaller than that of AlNiCo magnets. The magnetic stability in case of warming is considerably worse, herefore maximum working temperature may be no higher than 200°C. FERRIT magnets are hard and brittle and can only be ground.

Characteristics (typical)

Specific weight:	4.6 ... 5.1 g/cm³
Endurance limit:	50 N/mm²
Pressure resistance :	700 N/mm²
Mohs hardness:	6 ... 7
Thermal expansion:	8.5 ppm/°C
Specific resistance:	10^6 Ωm
Maximum working temperature:	250 °C
Temperature coefficient of Br:	0.2 %/°C

Chemical omposition

$6Fe_2O_3 \cdot BaO$

AlNiCo magnets

AlNiCo magnets are characterised by a high density of lines of force. Their good mechanical stability in case of heating permits their use in working temperatures of up to 500°C. Their macrocristalline structure is responsible for the hardness of AlNiCo magnets.

Please observe the following points:

- AlNiCo magnets must not be cut, broken or turned; the only means of processing is grinding.
- AlNiCo magnets are sensitive to magnetic influences and inadequate manipulation.
- AlNiCo magnets may only be brought in contact with iron or other magnets on their pole surfaces. (In case of contact with a magnet, on the opposite pole).
- Poles of the same denominator must never be pressed on top of each other.
- Do not separate pole shielding plates or magnets which shortcircuit each other by sliding them off each other; break them off.
- AlNiCo magnets allow working temperatures of up to 500°C.
- The paint of those varnished red is heat-resistant up to a maximum temperature of 120°C.
- The magnetic force of AlNiCo magnets decreases only in case of previous magnetic deterioration. Damaged magnets can regain their original force if they are remagnetised.

Characteristics (typical)

Tensile strength: Compression strength:	not indicated because of an inclination to interior fissures
Specific weight:	6.9 ... 7.3 g/cm³
Thermal expansion coefficient:	11 ... 14 ppm/°C
Thermal conductivity:	similar to that of steel
Curie temperature:	700 ... 850 °C
Maximum working temperature:	450 ... 500 °C
Temperature coefficient of Br:	0.02 %/°C

Chemical composition

Al	07 ... 12 %
Ni	14 ... 20 %
Co	16 ... 40 %
Cu	3 ... 4 %
Ti	0 ... 10 %
Nb	0 ... 10 %
Fe	remaining part

AlNiCo alloys are less inclined to rust than ordinary steel, however, they are not rust- and acid-proof. AlNiCo alloys are not resistant against strong alcaline solutions because of their high aluminium content. The following possibilities offer suitable protection against rust: stove enamel finish, burnishing, electroplating (only possible for non-magnetised magnets).

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Plasto-ferrite magnets (PF)

The problem of brittleness of FERRITE magnets has been solved by mixing pulverized ferrite with synthetic rubber. PLASTOFERRITE magnets can be produced in the shape of foils and profiles; they are flexible and can be cut with scissors and knives. Their magnetic characteristics are similar to those of the FERRITE magnets. Their magnetic values, however, are approximately two thirds lower. The maximum working temperature is approximately 80°C.

The magnetic material is also available with self-adhesive coating. Self-adhesive coating, however, is not recommended for extruded Plasto-ferrite profiles. The surface, which causes a technically difficult gluing process, cannot guarantee optimal adhesion.

The adhesive coatings of magnetic plates and foils produce optimal results for nearly every kind of application.However, tests are recommended to determine the adhesive properties of products before an application is decided upon.

General tolerances for magnetic foil cut-outs

Dimension	> 6 ... 30 mm	= ± 0.5 mm
	> 30 ... 120 mm	= ± 0.8 mm
	> 120 ... 315 mm	= ± 1.2 mm
	> 315 ... 1000 mm	= ± 2.0 mm

=> smaller tolerances on request

Plasic bonded (MQ1) Neodymium-Iron-Boron magnets (NdFeB)

Special processing permits the production of flakes of NdFeB and their compression with duroplastic in simple shapes. Due to plastic bonding, this material can be processed with all kinds of traditional tools. The energy density, nevertheless, remains three times that of a standard FERRITE magnet. Because of the high intensity of coercitivity and the resulting high resistance against opposing magnetic fields, plastic-bonded NdFeB-magnets can be used as suitable replacements for AlNiCo magnets.

Characteristics (typical)

Specific weight:	6.0 g/cm³
Specific resistance:	180 Ωm
Maximum working temperatue:	120 °C
Bonding material:	Epoxy resin
Temperature coefficient of Br:	0.04 %/°C

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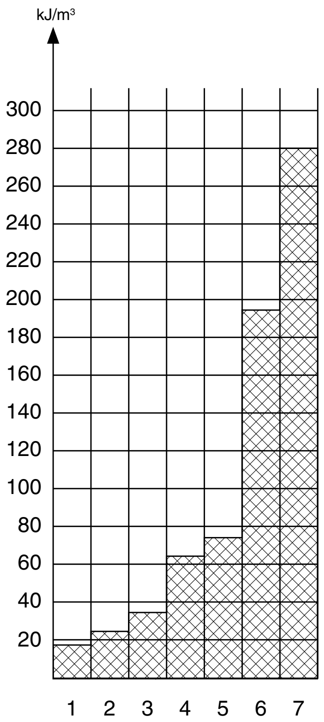
Comparison of energy density (BxH maximum value) of some magnetic material

1	Plastic-bonded hard ferrite, anisotropic	18 kJ/m³
2	Hard ferrite, sintered, anisotropic	25 kJ/m³
3	ALNiCo 45/5	36 kJ/m³
4	SmCo plastic-bonded	64 kJ/m³
5	NdFeB (MQ1) plastic-bonded	75 kJ/m³
6	Samarium-cobalt (SmCo)	195 kJ/m³
7	Neodymium-iron-boron	280 kJ/m³



Information concerning adhesive strength

The adhesive strengths indicated in the catalogue are approximate / standard values at a room-temperature of 20°C. They are valid for the vertical drawing off of the magnet from a polished steel plate (ST37) of a 10 millimetre thickness.

The corrosion stability of rare earths magnets

Rare earths magnets are classed with the metallic materials and therefore, they show the typical properties of these materials. This means, for example, that magnets oxidise when they are exposed to a humid atmosphere. However, by means of the adding by alloying of more precious elements, such as for example cobalt, the reaction with water can be virtually allayed. Therefore, SmCo-magnets acquire only a slight oxidisation of the surface, even when exposed to high levels of air humidity.

Sintered NdFeB-magnets contain, apart from the fixed, also free neodymium as part of their structure. As is the case with the majority of rare earths metals, this is in its free form extremely prone to corrosion and spontaneously forms neodymium oxide or neodymium hyoxide. NdFeB-magnets may even be attacked as a result of exposure to air humidity, dew or the perspiration of the hands, and show extremely strong reactions of corrosion when they are in contact with salts and acids. Higher levels of resistance to such influences can be achieved by appropriate coating.

Of the latest generations of neodymium magnets, the materials N45 and N48 have produced the best corrosion stability.
However, appropriate coating remains highly recommended, even for these magnet materials.

The adhering process of rare earths magnets

Many magnets are fixed by means of an adhesive technique when further processed. Apart from properties of material and kinds of use, possible external influences also have to be considered in this adhering process. Because of this reason, we recommend specific counselling by your adhesive supplier.

Experience has taught us that, particularly in the case of neodymium magnets, acidic adhesives must not be employed. Such adhesives may cause a rapid erosive reaction on the fringe surface of the magnetic material. This phenomenon may, however, also occur when coated magnets are employed, moreover, the process may be further enhanced by humidity.

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Differences between gripping and tractive magnets

The function of gripping magnets is to firmly hold objects placed against them. They need not have a great throwing power. Tractive magnets, on the other hand, must draw objects from a distance and must have great throwing power .

A good grip is best achieved with a small gap between the poles. Tractive magnets, on the other hand, require widely-spaced poles. In conclusion, it can be argued that the distance between the poles should be approximately that of the required throwing power of the magnet. The greater the throwing power of the magnet, the farther apart st the magnet poles must be.

It is important to know that the magnetic attraction is not determined by the magnet alone. The object to be attracted and its thickness is equally important.

Stability against external magnetic fields

In the same way as every magnet can be demagnetised by a sufficiently strong field opposed to magnetisation, every demagnetised field weakens the magnet up to a certain point. The performance of a newly remagnetised magnet is subject to a demagnetising force for the first time when taken out of the magnetising device. The insertion of an air gap in a magnetic circuit is equivalent to a demagnetising force. It causes induction to decrease to a lower value, and simultaneously stabilises the magnet at this value. This is the case of magnets delivered in a magnetised state, which remains until a stronger demagnetising force further weakens the magnet, stabilises at a lower value, and so forth.

A simple method to avoid demagnetisation, or to stabilise magnets is, therefore, to expose the fully magnetised magnets to an opposing magnetic field which is slightly stronger than the one they are later subjected to under working conditions.

System magnets

System magnets consist of magnetic material and pieces of conductive iron. The use of pieces of conductive iron has numerous advantages, the importance of which is listed below:

1. *Iron permits a higher density of lines of force than permanent magnetic matter. This can be observed e.g. in a superior lifting power,*
2. *Iron, in contrast to FERRITE and AlNiCo magnets, can be processed more easily.*
3. *The lines of force in iron can be deviated and concentrated.*
4. *Magnetic materials can be more efficiently exploited.*
5. *Magnetic constructions tend to become simpler and less expensive.*

The magnetic characteristics and the maximum working temperatures of SYSTEM magnets depend on the materials used.

Tolerances

Tolerances are very often indicated for measurments, irrespective of whether they are necessary or not. The reason for this probably stems from the fact that the tolerances indicated for other work pieces are simply taken over.

It is wrong, however, to indicate tolerances in principle for all measurments of permanent magnets. It is, however, correct to prescribe tolerances for «casting» or «sintering», wherever this is possible. Checking always costs money , even if it is not necessary to grind the magnets to keep the tolerances.

The entry check of many users consists only of dimension and quality of surface. The most important check, however, the one concerning magnetic performance, is often neglected. Magnets with irregularities of surface or small fissures are rejected, because it is mistakenly supposed that this diminishes the magnetic performance.

Defectiveness of surface and small fissures do not influence the magnetic performance in any way. To accept such irregularities reduces the number of rejects and consequently the price.

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Dimensioning of magnets with the help of the demagnetisation curve

Magnets cannot, as other construction parts, be constructed or defined at random. The dimensioning of pole face respective to length in direction of magnetisation must correspond with the required magnetic values.

The maximum magnetic energy is obtained if the product of remanence B and the coercive field intensity H attain a maximum. This is the case if the largest possible rectangle can be formed under the demagnetisation characteristic curve of B to H (see graph).

The diagram below contains, in its margin, a scale indicating the relationship of the length to the diameter of a magnet (relationship L/D).

For a magnetic disk of 10 mm in diameter x 5 mm thickness, the L/D relationship is equal to 5:10 = 0.5. If a line is drawn from mark 0.5 to the zero point, the intersection on the characteristic curve of the corresponding magnetic material is the operating point (BxH) of this magnetic disk.

If this operating point is horizontally connected with the B axis and vertically with the H axis, the remanence and the coercive field intensity can be read.

If B and H have the largest possible values, the operating point is situated in the (BxH) maximum value.

For an «open» magnet, which is used without steel-pole plate, or iron poles, the dimensioning should be chosen in such a manner that the operating point is situated in the proximity of the maximum value (BxH).

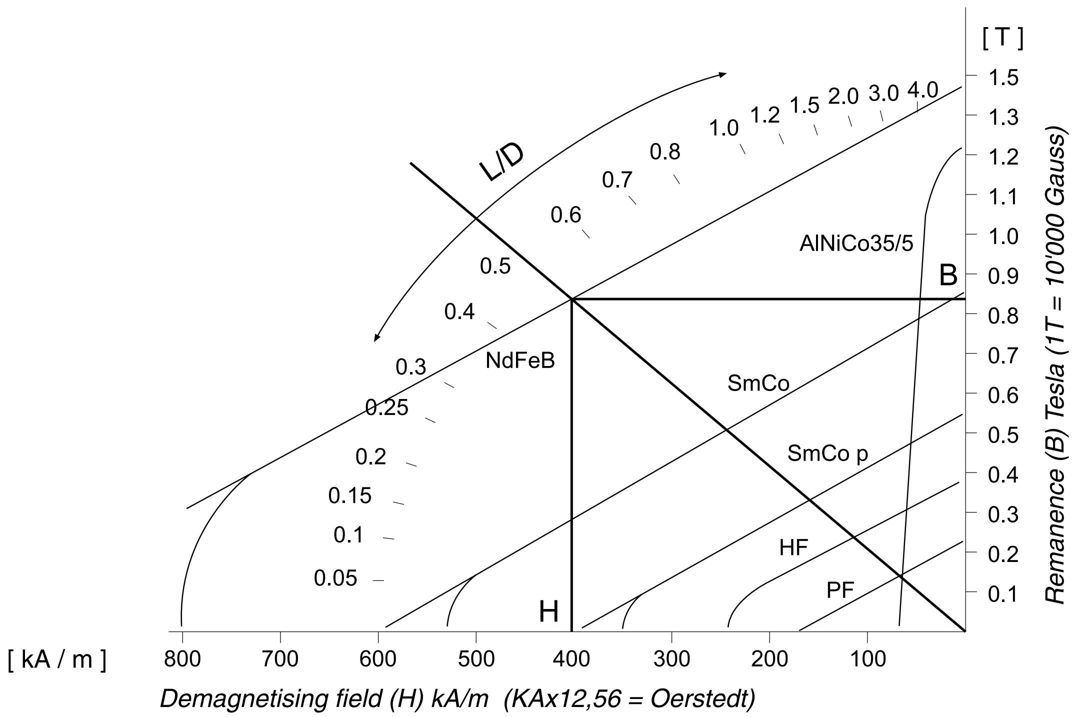
For square or almost square magnetic pole faces, the pole face can be converted according to the following formula.

$$D = \sqrt{\frac{a \times b \times 4}{\pi}}$$

oder

$$D = \sqrt{\frac{A \cdot 4}{\pi}}$$

The curves, indicated below, for the different magnetic mterials are simplified and represented without temperature characteristics. A difference in temparature causes a shift of the operating point on the characteristic curve. As long as the operating point remains in the linear range of the demagnetising characteristic curve, the induction alters reversibly, i.e. after cooling off, it reverts to the original value. Otherwise, the alteration of the induction remains irreversible and can only be reversed by means of renewed remagnetisation.



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