Magnetic products for engineering performance, innovation and design.

ADAMS®
MAGNETIC PRODUCTS

Magnetic products for engineering performance, innovation and design.

Founded in 1950, Adams Magnetic Products is a custom manufacturer, fabricator and distributor of all types of permanent magnets, magnetic assemblies and devices.

Our technical experts are ready to answer your questions and address your magnetic needs. Whether it's selecting a magnet to fit an application, choosing the most cost effective material or reviewing options from what is available in the market, we are here to help with:

- Application and Design Engineering Assistance
- Testing/Analysis of Magnetic Materials
- Magnetic Circuit Analysis/FEA
- Value Analysis/Value Engineering Support
- Inventory Management Programs

A Commitment to Value

We define value as having the right products available at the right time and delivering them as promised, defect-free, at competitive prices. Adams is committed to delivering outstanding value to customers at every opportunity.

Certified Quality Management

Adams maintains ISO 9001:2015 certification, reinforcing our strong operational processes and commitment to continual improvement. We have a standard of zero defects in everything we do.

Military and Defense Materials

Adams Magnetic Products has the knowledge, understanding and systems in place to fully comply with the Arms Export Control Act (AECA) and International Traffic in Arms Regulations (ITAR). We are your partner in fabricating magnets and magnetic products for the defense and military industries. As an ITAR registered supplier, you can rest assured your data and confidential information is safe with us. We are also your source for Defense Acquisition Regulations System (DFARS) compliant materials. Let our technical staff assist you in obtaining the right materials for your DoD needs.

Content

Glossary of magnetic terms

CLOSED CIRCUIT CONDITION: When the external flux path of a permanent magnet is confined with high permeability material, it creates what is known as closed circuit condition.

COERCIVITY: When an attempt is made to demagnetize a magnet, coercivity describes the measure of what is necessary to achieve this goal. It refers to the strength of the reverse magnetic field required for demagnetization of a permanent magnet.

COERCIVE FORCE (Hc): Similar to coercivity, this is the specific demagnetizing force necessary to lower the residual induction (Br) of a fully magnetized magnet to zero.

CURIE TEMPERATURE (Tc): The temperature point beyond which magnetic materials lose their magnetic properties is known as the Curie temperature.

DEMAGNETIZATION CURVE: This is the specific term for the second (or fourth) quadrant of a major hysteresis loop. The points on this curve are designated by the coordinates Bd and Hd.

GAUSS (B): This is a unit of magnetic flux density equal to 1 maxwell per square centimeter.

HYSTERESIS LOOP: One way to learn more about a magnet's magnetic properties is to study its hysteresis loop. It is generated by measuring the magnetic flux while the magnetizing force is changed. Specifically, this is a closed curve obtained for a material by plotting (usually to rectangular coordinates) corresponding values of magnetic induction, B, for ordinates and magnetizing force, H, for abscissa when the material is passing through a complete cycle between definite limits of either magnetizing force, H, or magnetic induction, B.

INTRINSIC COERCIVE FORCE (Hci): This is the term used to measure a magnetic material's ability to resist demagnetization. It is equal to the demagnetizing force, which reduces the intrinsic induction (Bi) in the material to zero after magnetizing to saturation.

IRREVERSIBLE LOSSES: These are defined as partial demagnetization of the magnet, caused by any number of factors, from exposure to high and low temperatures, and to external magnetic fields. Despite the 'irreversible' name, such losses are recoverable through re-magnetization. Magnets can be stabilized against irreversible losses by partial demagnetization induced by temperature cycles or by external magnetic fields.

MAGNETIC POLES: The points where a magnet's strength is concentrated are called the magnetic poles. Most people are familiar with the commonly used "north" and "south" designations, which refer to how suspended magnets orient along north-south planes. On different magnets, like poles repel each other, opposite poles attract.

MAXIMUM ENERGY PRODUCT (BHmax): This term refers to the quality index representing both the saturation magnetization and coercivity of a permanent magnet.

OERSTED (H): Named for the scientist heralded as the father of electromagnetism, an oersted is the unit of magnetic field strength in the cgs system. One oersted equals a magnetomotive force of one gilbert per centimeter of flux path.

OPEN CIRCUIT CONDITION: This is a condition that exists in a magnetized magnet when it is free from any external flux path of high permeability material.

ORIENTATION DIRECTION: Also known as "easy axis" or just "axis," orientation direction refers to the preferred direction in which some magnets (called oriented or anisotropic magnets) should be magnetized to achieve maximum magnetism. Other magnets, called unoriented or isotropic magnets, can be magnetized in any direction.

PERMEANCE COEFFICIENT (Pc): Permeance coefficient is also referred to as the shear line, load line, unit permeance, or operating slope. It is a straight line passing through the origin of the demagnetization curve with a slope of negative Bd/Hd. The permeance coefficient is calculated using the geometric parameters of the magnet or magnetic circuit. The primary purpose of calculating the permeance coefficient is to determine the operating point (Bd, Hd) of the magnet on the normal demagnetization curve. With two magnets of identical material grade and pole surface area, the longer of the two will have a greater permeance coefficient and therefore a greater B_d.

POLARITY OF A MAGNETIZED MAGNET: The North Pole of a magnet is that pole which is attracted to the geographic North Pole. Therefore, the North Pole of a magnet will repel the north-seeking pole of a magnetic compass.

RESIDUAL INDUCTION (Br): Residual induction is the magnetic induction corresponding to zero magnetic force in a magnetic material after full magnetization in a closed circuit. It is also sometimes referred to as flux density, and can be measured in gauss or Tesla.

TEMPERATURE COEFFICIENT: When temperature changes, there may be reversible changes in magnetic properties. The temperature coefficient is the factor that describes these changes, and is expressed as the % change per unit of temperature. The magnetic property spontaneously returns when the temperature is cycled to its original point.

Magnet Materials Overview

Neodymium Iron Boron

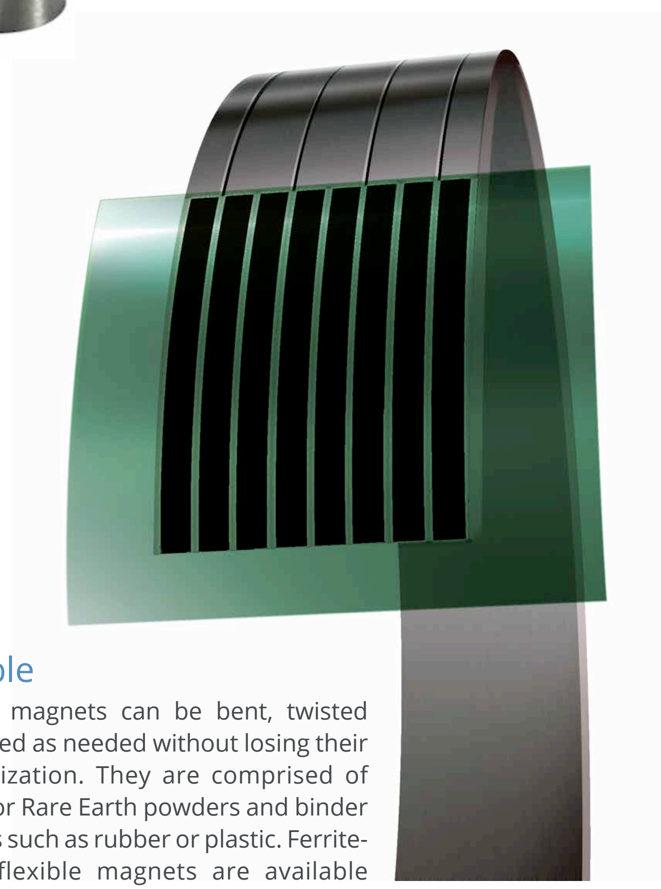
Among commercial magnet materials, the rare earth Neodymium Iron Boron magnet is the most powerful in the marketplace. In many cases it is a more economical alternative to Samarium Cobalt, but is only suitable for certain applications because of its temperature sensitivity and susceptibility to oxidation. Available in both sintered and bonded forms, this class of Rare Earth material possesses the highest Br, relatively high Hc and high BHmax. Neodymium Iron Boron has an approximate energy product range of 10-55 MGOe.

Alnico

Alnico magnets have been a mainstay of the industry since the 1930s. They are composed of aluminum, nickel, and cobalt, and available in both cast and sintered forms. The key benefits of Alnico magnets include temperature stability (over 500°C with no permanent magnetic loss), ease of demagnetization and high corrosion resistance. Alnico magnets exhibit high Br, but low Hc. Their energy product range is approximately 1.4-11 MGOe.

Samarium Cobalt

Like Neodymium Iron Boron, Samarium Cobalt is a class of Rare Earth material that is available in both sintered and bonded forms. The two materials share many of the same attributes, such as High Br, high Hc and relatively high BHmax. However, Samarium Cobalt is more resistant to corrosion than Neodymium iron boron. Samarium Cobalt has an approximate energy product range of 18-33 MGOe, and exhibits better temperature stability than Neodymium.



Ferrite (Ceramic)

Ferrite is the lowest cost magnet material currently available, which may be why sintered ferrite magnets are used in automotive small motor applications as well as in many other consumer products. Composed of Strontium Ferrite, these hard, brittle materials stand up well to demagnetization, except in extreme cold environments. Ferrite has an approximate energy product range of 1.1-4.5 MGOe.

Flexible

Flexible magnets can be bent, twisted and coiled as needed without losing their magnetization. They are comprised of Ferrite or Rare Earth powders and binder systems such as rubber or plastic. Ferrite-based flexible magnets are available from 0.6-1.8 MGOe, while those with Rare Earth-based materials can reach 6 MGOe. Grading varies by composition.

NEODYMIUM MATERIAL

Adams NdFeB	ASTM 1101-16	Residual Induction Br (kG)	Intrinsic Coercivity Hci (kOe)	Coercive Force Hc (kOe)	BHmax Energy (MGOe)	Max. Temp. (°C/°F)*	TC of Br (%/°C)	TC of Hci (%/°C)
Neo2825 (UH)	ND-SA-207/1989	10.2~10.8	≥25	≥9.6	25~28	180/356	-0.12	-0.70
Neo2830 (EH)	ND-SA-207/2387	10.4~10.9	≥30	≥9.8	25~28	200/392	-0.12	-0.70
Neo2834 (AH)	ND-SA-207/2785	10.2~10.9	≥34	≥9.8	25~29	230/446	-0.12	-0.70
Neo3020 (SH)	ND-SA-222/1592	10.8~11.3	≥20	≥10.1	28~31	150/302	-0.12	-0.70
Neo3025 (UH)	ND-SA-222/1989	10.8~11.3	≥25	≥10.2	28~31	180/356	-0.12	-0.70
Neo3030 (EH)	ND-SA-222/2387	10.8~11.3	≥30	≥10.2	28~31	200/392	-0.12	-0.70
Neo3034 (AH)	ND-SA-222/2785	10.7~11.3	≥34	≥10.2	27~31	230/446	-0.12	-0.70
Neo3312 (N)	ND-SA-244/955	11.3~11.7	≥12	≥10.5	31~34	80/176	-0.12	-0.70
Neo3314 (M)	ND-SA-244/1114	11.3~11.7	≥14	≥10.5	31~34	100/212	-0.12	-0.70
Neo3317 (H)	ND-SA-244/1353	11.3~11.7	≥17	≥10.5	31~34	120/248	-0.12	-0.70
Neo3320 (SH)	ND-SA-244/1592	11.3~11.7	≥20	≥10.6	31~34	150/302	-0.12	-0.70
Neo3325 (UH)	ND-SA-244/1989	11.3~11.7	≥25	≥10.7	31~34	180/356	-0.12	-0.70
Neo3330 (EH)	ND-SA-244/2387	11.3~11.7	≥30	≥10.8	31~34	200/392	-0.12	-0.70
Neo3333 (AH)	(none)	11.1~11.7	≥33	≥10.8	30~34	230/446	-0.12	-0.70
Neo3512 (N)	ND-SA-259/955	11.7~12.2	≥12	≥10.9	33~36	80/176	-0.12	-0.70
Neo3514 (M)	ND-SA-259/1114	11.7~12.2	≥14	≥10.9	33~36	100/212	-0.12	-0.70
Neo3517 (H)	ND-SA-259/1353	11.7~12.2	≥17	≥10.9	33~36	120/248	-0.12	-0.70
Neo3520 (SH)	ND-SA-259/1592	11.7~12.2	≥20	≥11.0	33~36	150/302	-0.12	-0.70
Neo3525 (UH)	ND-SA-259/1989	11.7~12.2	≥25	≥11.1	33~36	180/356	-0.12	-0.70
Neo3530 (EH)	ND-SA-259/2387	11.7~12.2	≥30	≥11.1	33~36	200/392	-0.12	-0.70
Neo3533 (AH)	(none)	11.7~12.2	≥33	≥11.1	33~36	230/446	-0.12	-0.70
Neo3812 (N)	ND-SA-281/955	12.2~12.5	≥12	≥11.3	36~39	80/176	-0.12	-0.70
Neo3814 (M)	ND-SA-281/1114	12.2~12.5	≥14	≥11.3	36~39	100/212	-0.12	-0.70
Neo3817 (H)	ND-SA-281/1353	12.2~12.5	≥17	≥11.3	36~39	120/248	-0.12	-0.70
Neo3820 (SH)	ND-SA-281/1592	12.2~12.5	≥20	≥11.4	36~39	150/302	-0.12	-0.70
Neo3825 (UH)	ND-SA-281/1989	12.2~12.5	≥25	≥11.5	36~39	180/356	-0.12	-0.70
Neo3830 (EH)	ND-SA-281/2387	12.0~12.5	≥30	≥11.5	35~39	200/392	-0.12	-0.70
Neo3833 (AH)	(none)	12.2~12.6	≥33	≥11.6	36~39	220/428	-0.12	-0.70
Neo4012 (N)	ND-SA-296/955	12.5~12.8	≥12	≥11.6	38~41	80/176	-0.12	-0.70
Neo4014 (M)	ND-SA-296/1114	12.5~12.8	≥14	≥11.6	38~41	100/212	-0.12	-0.70
Neo4017 (H)	ND-SA-296/1353	12.5~12.8	≥17	≥11.6	38~41	120/248	-0.12	-0.70
Neo4020 (SH)	ND-SA-296/1592	12.5~12.8	≥20	≥11.8	38~41	150/302	-0.12	-0.70
Neo4025 (UH)	ND-SA-296/1989	12.5~12.8	≥25	≥11.8	38~41	180/356	-0.12	-0.70
Neo4030 (EH)	(none)	12.5~12.9	≥30	≥11.8	38~41	190/374	-0.12	-0.70
Neo4212 (N)	ND-SA-311/955	12.8~13.2	≥12	≥11.6	40~43	80/176	-0.12	-0.70
Neo4214 (M)	ND-SA-311/1114	12.8~13.2	≥14	≥12.0	40~43	100/212	-0.12	-0.70
Neo4217 (H)	ND-SA-311/1353	12.8~13.2	≥17	≥12.0	40~43	120/248	-0.12	-0.70
Neo4220 (SH)	ND-SA-311/1592	12.8~13.2	≥20	≥12.2	40~43	150/302	-0.12	-0.70
Neo4225 (UH)	ND-SA-311/1989	12.7~13.2	≥25	≥12.2	40~43	170/338	-0.12	-0.70
Neo4229 (EH)	(none)	12.8~13.2	≥29	≥12.2	39~43	180/356	-0.12	-0.70
Neo4512 (N)	ND-SA-333/955	13.2~13.7	≥12	≥11.6	43~46	80/176	-0.12	-0.70
Neo4514 (M)	ND-SA-333/1114	13.2~13.7	≥14	≥12.5	43~46	100/212	-0.12	-0.70
Neo4517 (H)	ND-SA-333/1353	13.2~13.7	≥17	≥12.5	43~46	120/248	-0.12	-0.70
Neo4520 (SH)	ND-SA-333/1592	13.2~13.7	≥20	≥12.5	43~46	140/284	-0.12	-0.70
Neo4525 (UH)	ND-SA-333/1989	13.2~13.7	≥24	≥12.5	43~47	160/320	-0.12	-0.70
Neo4812 (N)	ND-SA-355/955	13.7~14.2	≥12	≥11.6	45~49	80/176	-0.12	-0.70
Neo4814 (M)	ND-SA-355/1114	13.6~14.2	≥14	≥12.8	45~49	100/212	-0.12	-0.70
Neo4817 (H)	ND-SA-355/1353	13.6~14.2	≥17	≥12.9	45~49	110/230	-0.12	-0.70
Neo4820 (SH)	ND-SA-355/1592	13.6~14.2	≥20	≥12.9	45~49	130/266	-0.12	-0.70
Neo5012 (N)	ND-SA-370/955	13.9~14.4	≥12	≥11.6	47~51	60/132	-0.12	-0.70
Neo5014 (M)	ND-SA-370/1114	13.9~14.4	≥14	≥13.0	47~51	90/194	-0.12	-0.70
Neo5016 (H)	ND-SA-370/1353	13.9~14.4	≥16	≥13.0	47~51	100/212	-0.12	-0.70
Neo5211 (N)	ND-SA-385/875	14.3~14.8	≥11	≥10.5	49~53	60/140	-0.12	-0.70
Neo5213 (M)	ND-SA-385/955	14.2~14.7	≥13	≥12.5	49~53	80/176	-0.12	-0.70

This is not a comprehensive listing of all available grades. Please contact us with your specific requirements.

SAMARIUM COBALT MATERIAL 1:5 SERIES

Adams SmCo	ASTM 1102-16	Residual Induction Br (kG)	Intrinsic Coercivity Hci (kOe)	Coercive Force Hc (kOe)	BHmax Energy (MGOe)	Max. Temp. (°C/°F)*	TC of Br (%/°C)	TC of Hci (%/°C)
SmCo 18	S1-SA-120/1600	8.4~8.9	≥23	8.1~8.6	17-19	250/482	-0.040	-0.30
SmCo 20	S1-SA-140/1200	8.9~9.3	≥23	8.6~9.1	19-21	250/482	-0.045	-0.30
SmCo 22	S1-SA-160/1200	9.2~9.6	≥23	8.6~9.4	21-23	250/482	-0.045	-0.30
SmCo 24	S1-SA-170/700	9.6~10.0	≥23	9.3~9.8	22-24	250/482	-0.045	-0.30
SmCoLTC10		6.2~6.6	≥23	6.1~6.5	9.5-11	300/572	Temp.	Br%/°C
							20-100°C	+0.0156
							100-200°C	+0.0087
							200-300°C	+0.0007

SAMARIUM COBALT MATERIAL 2:17 SERIES

SmCo2218	S2-SA-160/700	9.3~9.7	≥ 18	8.5~9.3	20-23	300/572	-0.020	-0.20
SmCo2418	S2-SA-172/529	9.5~10.2	≥ 18	8.7~9.6	22-24	300/572	-0.025	-0.20
SmCo2618	S2-SA-186/756	10.2~10.5	≥ 18	9.4~10.0	24-26	300/572	-0.030	-0.20
SmCo2818	S2-SA-201/529	10.3~10.8	≥ 18	9.5~10.2	26-28	300/572	-0.035	-0.20
SmCo3018	S2-SA-220/1500	10.8~11.5	≥ 18	9.9~10.5	28-30	300/572	-0.035	-0.20
SmCo3218	S2-SA-230/1134	11.0~11.5	≥ 18	10.2~10.7	29-32	300/572	-0.035	-0.20
SmCo3318		11.4~11.7	≥ 18	8.2~10.4	31-34	250/482	-0.040	-0.20
SmCo2425	S2-SA-172/1966	9.5~10.2	≥ 25	8.7~9.6	22-24	350/662	-0.025	-0.20
SmCo2625	S2-SA-186/1966	10.2~10.5	≥ 25	9.4~10.0	24-26	350/662	-0.030	-0.20
SmCo2825	S2-SA-201/1966	10.3~10.8	≥ 25	9.5~10.2	26-28	350/662	-0.035	-0.20
SmCo3025	S2-SA-215/1814	10.8~11.0	≥ 25	9.9~10.5	28-30	350/662	-0.035	-0.20
SmCo3225	S2-SA-230/1890	11.0~11.3	≥ 25	10.2~10.7	29-32	350/662	-0.035	-0.20
SmCoLTC22		9.4~9.8	15-20	8.4~9.0	22-24	300/572	Temp.	Br%/°C
							-50-25°C	+0.005
							20-100°C	-0.008
							100-200°C	-0.008
							200-300°C	-0.011

ALNICO MATERIAL

Adams Alnico	ASTM 1070-16	Residual Induction Br (G)	Intrinsic Coercivity Hci (Oe)	Coercive Force Hc (Oe)	BHmax Energy (MGOe)	Max. Temp. (°C/°F)*	TC of Br (%/°C)	TC of Hci (%/°C)
Cast Alnico 2	AL-CI-12/44	7,100	560	550	1.5	550/1020	-0.02	-
Cast Alnico 3	AL-CI-10/38	6,000	560	550	1.25	550/1020	-0.02	-
Cast Alnico 5	AL-CA-39/49	12,300	610	600	5.0	550/1020	-0.02	-
Cast Alnico 5-7	AL-CA-54/56	13,000	730	720	7.0	550/1020	-0.02	-
Cast Alnico 8	AL-CA-38/141	8,000	1,400	1,380	4.75	550/1020	-0.02	-
Cast Alnico 9	AL-CA-65/115	10,800	1,520	1,500	10.0	550/1020	-0.02	-
Sintered Alnico 2	AL-S1-11/43	6,700	610	600	1.5	450/840	-0.02	-
Sintered Alnico 5	AL-SA-28/48	12,000	610	600	4.25	450/840	-0.02	-
Sintered Alnico 8	AL-SA-29/128	8,000	1,620	1,600	5.25	450/840	-0.02	-

above values are nominal properties

CERAMIC MATERIAL

Adams Ceramic	ASTM 1054-16	Residual Induction Br (G)	Intrinsic Coercivity Hci (Oe)	Coercive Force Hc (Oe)	BHmax Energy (MGOe)	Max. Temp. (°C/°F)*	TC of Br (%/°C)	TC of Hci (%/°C)
Ceramic 1	CE-I-01	2,300	3,000	1,850	1.0	399/750	-0.2	0.2~0.5
Ceramic 5	CE-A-05	3,950	2,500	2,400	3.4	399/750	-0.2	0.2~0.5
Ceramic 8a	CE-A-08A	3,900	3,050	2,950	3.5	399/750	-0.2	0.2~0.5
Ceramic 8b	CE-A-08B	4,200	2,950	2,900	4.1	399/750	-0.2	0.2~0.5
Ceramic 8c	(none)	4,300	2,750	2,700	4.2	399/750	-0.2	0.2~0.5

above values are nominal properties

*Maximum operating temperatures are for a magnet geometry with a corresponding Operating Slope of 1

Neodymium

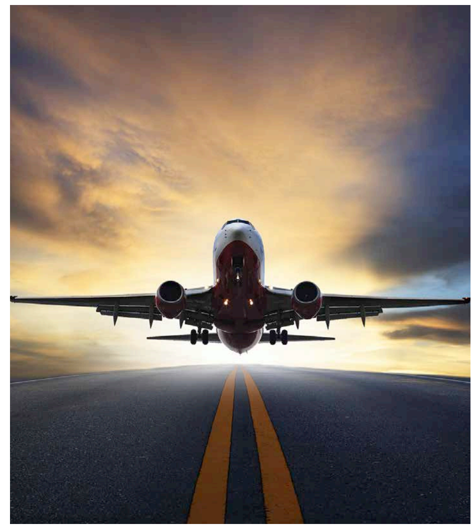
Neodymium magnets are the strongest known type of permanent magnet.

Neodymium Magnetizing and Machining

Neodymium magnets cannot be machined with conventional drilling, turning or milling processes, and must be ground before they are magnetized. Large or complex assemblies are usually magnetized prior to assembly. Standard tolerances are +/-.005 on ground dimensions.

Neodymium requires high magnetizing fields, and offers substantial resistance to demagnetization. Sintered NdFeB magnets are manufactured with a preferred direction of magnetic orientation (anisotropic) prior to magnetizing. The following magnetization process must consider the anisotropy direction to achieve full magnetic specifications.

In some configurations, utilizing custom magnetizing features can produce multipole magnetization on a single magnet.



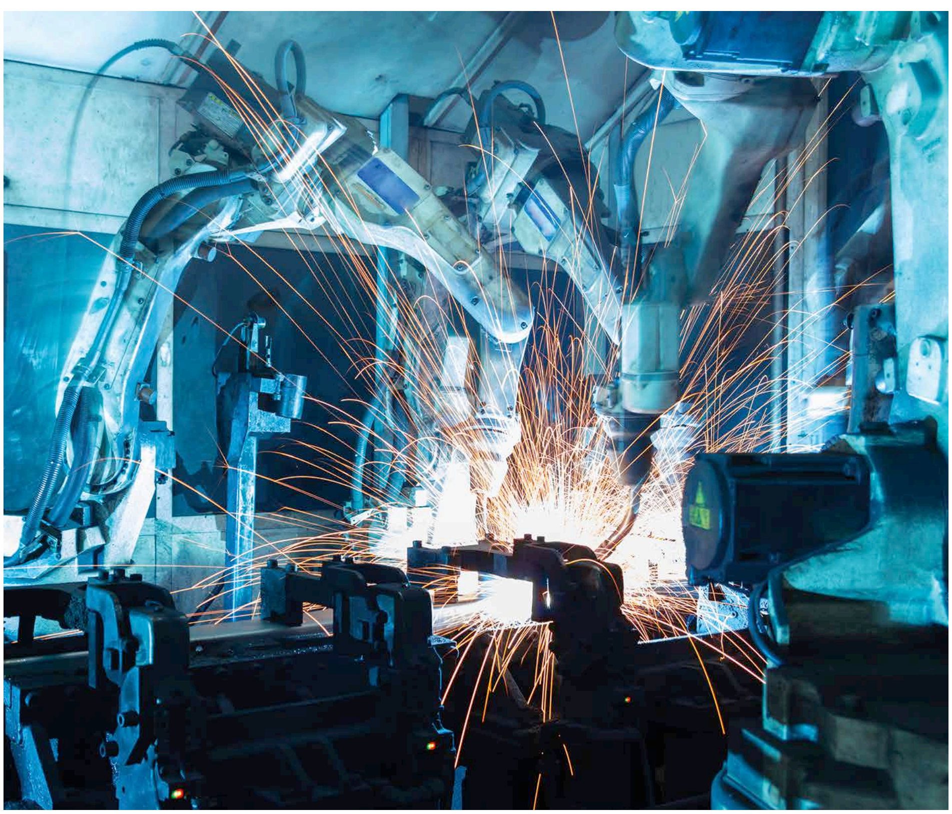
Temperature Considerations with Neodymium Magnets

The need for low temperature coefficient in Neodymium magnet applications has triggered the development of several grades to meet specific operating requirements (see Magnetic Properties chart).

Depending on the operating slope, a low coercivity grade Neodymium magnet may begin to lose strength if heated above 176°F (80°C). High coercivity grade Neodymium Magnets can function at temperatures up to 446°F (230°C) with little irreversible loss.

Neodymium Magnet Applications

Neodymium magnets have replaced Alnico and ferrite magnets in many applications, including: head actuators for computer hard disks, magnetic resonance imaging (MRI), loudspeakers and headphones, magnetic bearings and couplings, cordless tools, servo motors, lifting and compressor motors, synchronous motors, spindle and stepper motors, electrical power steering, drive motors for hybrid and electric vehicles, and actuators.



Corrosion Protection

Neodymium Iron Boron (NdFeB) permanent magnets are all susceptible to corrosive degradation. Over time this corrosion will inhibit magnetic performance, but this can be prevented through a multi-layer plating of nickel, copper and nickel (Ni-Cu-Ni). This coating offers a high level of corrosion protection for the value.

Other coatings are also available, each with properties that make them more or less suited to a particular working environment. Please see the table below for a general list of coatings/platings and their respective performance under commonly seen conditions. You are invited to contact one of our applications experts to determine which plating or coating is best for your needs.

COATINGS PERFORMANCE TABLE

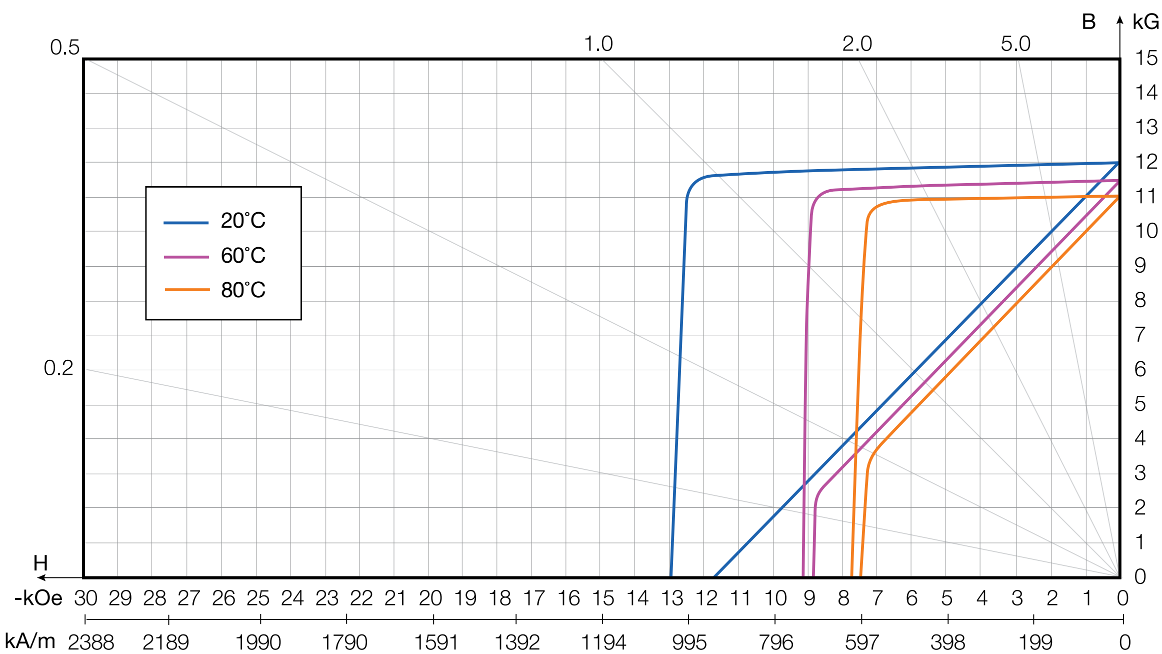
Coating	Color	Approx. Thickness (μ m)	Salt fog	Salt Water	Humidity	Water	Abrasion Resistance	Relative Cost
Nickel Copper Nickel	Bright	10-20	Poor	Poor	Fair	Fair	Excellent	Lowest
Zinc Blue	White	8-10	Fair	Poor	Good	Fair	Good	Low
Zinc W/ Chromate	Multi-color	8-10	Fair	Poor	Good	Fair	Good	Low
Nickel Tin	Silver White	12	Good	Fair	Good	Good	Good	Medium
Nickel Silver	Silver	10-15	Good	Fair	Excellent	Good	Fair	High
Nickel Gold	Gold	10-15	Good	Fair	Excellent	Good	Fair	High
Epoxy	Black, Grey	15-30	Excellent	Excellent	Excellent	Good	Poor	Medium
Everlube	Gold Metallic	8-15	Good	Good	Excellent	Excellent	Fair	High
Nickel Copper Everlube	Gold Metallic	15-25	Excellent	Excellent	Excellent	Excellent	Good	High
Parylene C	Clear	10 – 25	Excellent	Excellent	Excellent	Excellent	Poor	Highest
Phenolic Resin	Black	13	Excellent	Excellent	Excellent	Excellent	Excellent	High
AL (PVD)	Silver, Grey	2	Poor	Poor	Fair	Poor	Excellent	Highest

Neodymium 3512

Magnetic characteristics

Br (kG)	11.7~12.2	MAX OP TEMP 80˚C/176˚F OPERATING SLOPE OF 1	
Hci (kOe)	≥12		
Hc (kOe)	≥10.9	Tc of Br (%/˚C)	-0.12
BHmax (MGOe)	33~36	Tc of Hci (%/˚C)	-0.70

Typical demagnetization curves B(H) and J(H) at various temperatures:



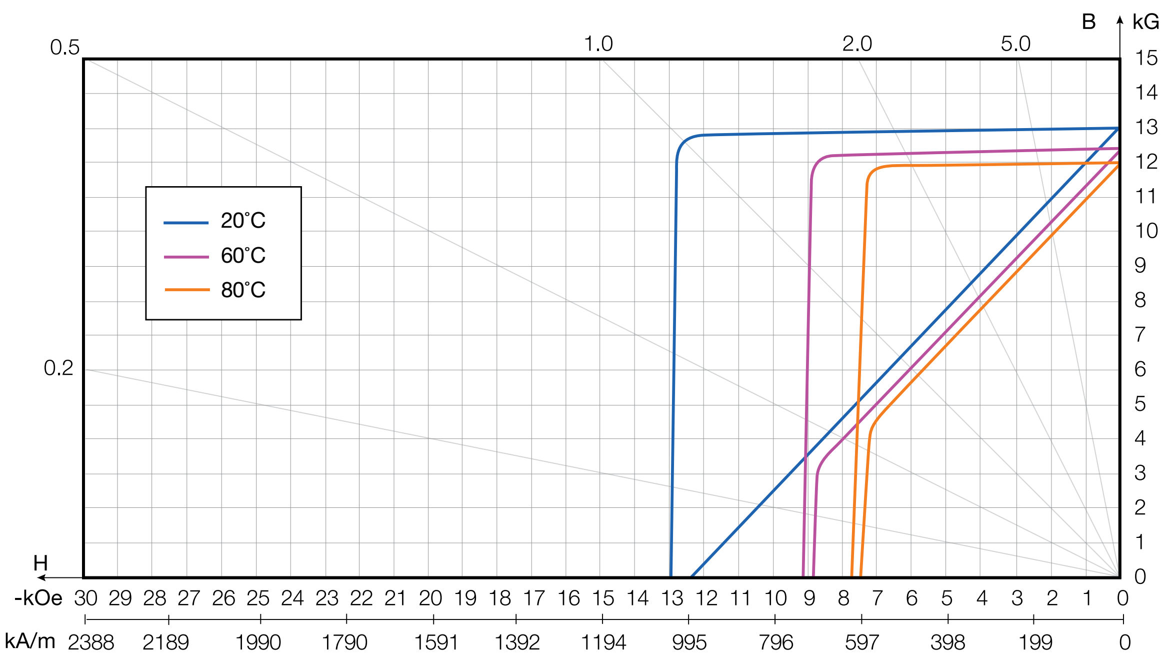
Curves for other material grades are available upon request.

Neodymium 4212

Magnetic characteristics

Br (kG)	12.8~13.2	MAX OP TEMP OPERATING SLOPE OF 1	80˚C/176˚F
Hci (kOe)	≥12		
Hc (kOe)	≥11.6	Tc of Br (%/˚C)	-0.12
BHmax (MGOe)	40~43	Tc of Hci (%/˚C)	-0.70

Typical demagnetization curves B(H) and J(H) at various temperatures:



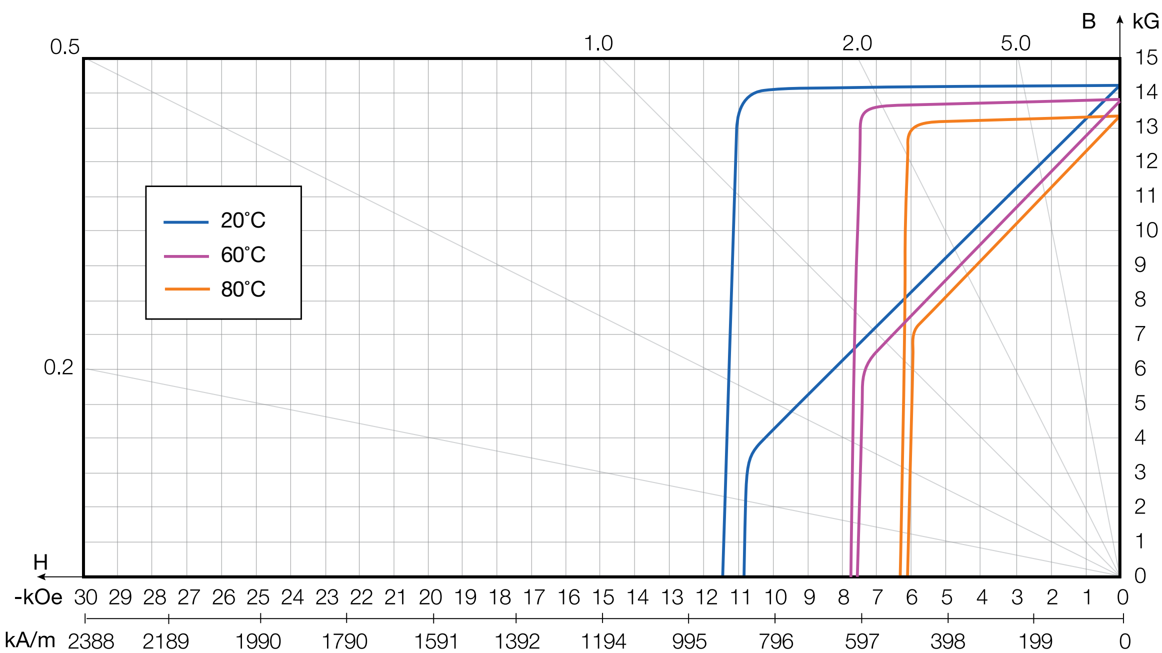
Curves for other material grades are available upon request.

Neodymium 5211

Magnetic characteristics

Br (kG)	14.3~14.8	MAX OP TEMP 60˚C/140˚F OPERATING SLOPE OF 1	
Hci (kOe)	≥11		
Hc (kOe)	≥10.5	Tc of Br (%/˚C)	-0.12
BHmax (MGOe)	49~53	Tc of Hci (%/˚C)	-0.70

Typical demagnetization curves B(H) and J(H) at various temperatures:



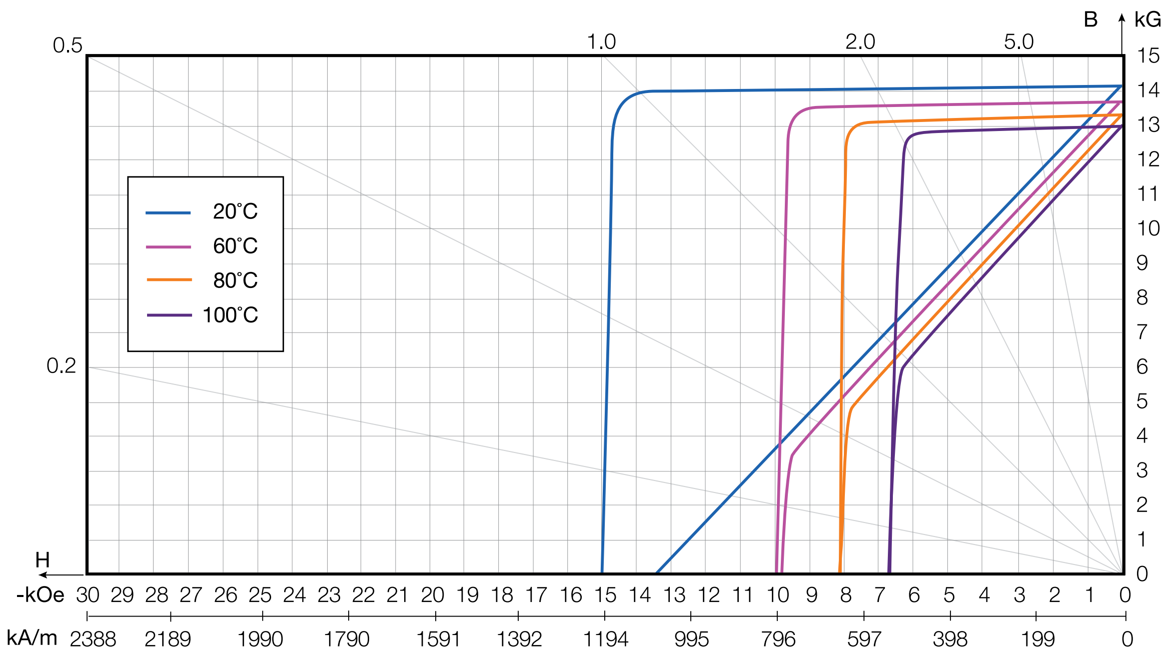
Curves for other material grades are available upon request.

Neodymium 5014

Magnetic characteristics

Br (kG)	13.9~14.4	MAX OP TEMP OPERATING SLOPE OF 1	90˚C/194˚F
Hci (kOe)	≥14		
Hc (kOe)	≥13	Tc of Br (%/˚C)	-0.12
BHmax (MGOe)	47~51	Tc of Hci (%/˚C)	-0.70

Typical demagnetization curves B(H) and J(H) at various temperatures:



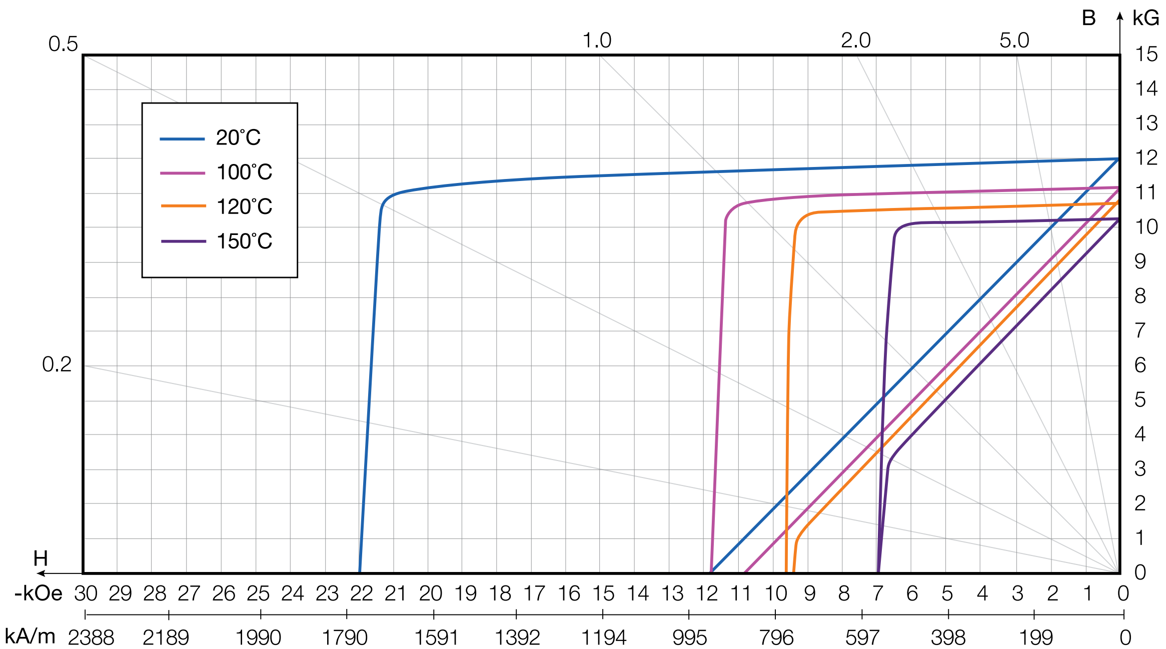
Curves for other material grades are available upon request.

Neodymium 3520

Magnetic characteristics

Br (kG)	11.7~12.2	MAX OP TEMP	150˚C/302˚F
Hci (kOe)	≥20	OPERATING SLOPE OF 1	
Hc (kOe)	≥11.0	Tc of Br (%/˚C)	-0.12
BHmax (MGOe)	33~36	Tc of Hci (%/˚C)	-0.70

Typical demagnetization curves B(H) and J(H) at various temperatures:

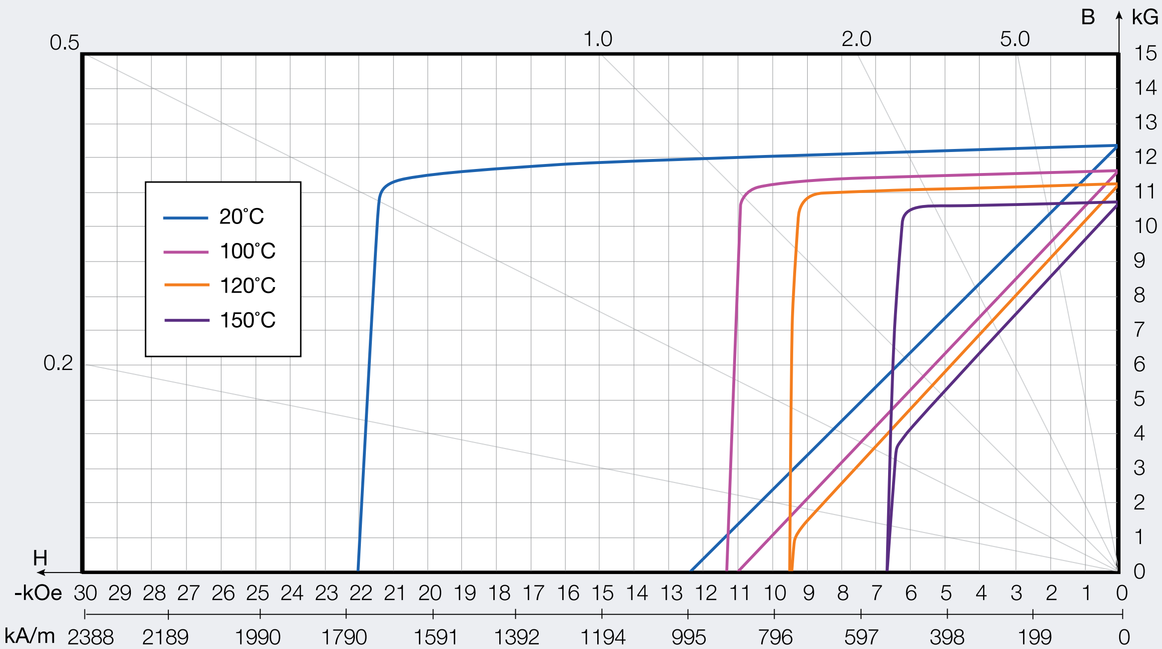


Neodymium 3820

Magnetic characteristics

Br (kG)	12.2~12.5	MAX OP TEMP OPERATING SLOPE OF 1	150˚C/302˚F
Hci (kOe)	≥20		
Hc (kOe)	≥11.4	Tc of Br (%/˚C)	-0.12
BHmax (MGOe)	36~39	Tc of Hci (%/˚C)	-0.70

Typical demagnetization curves B(H) and J(H) at various temperatures:



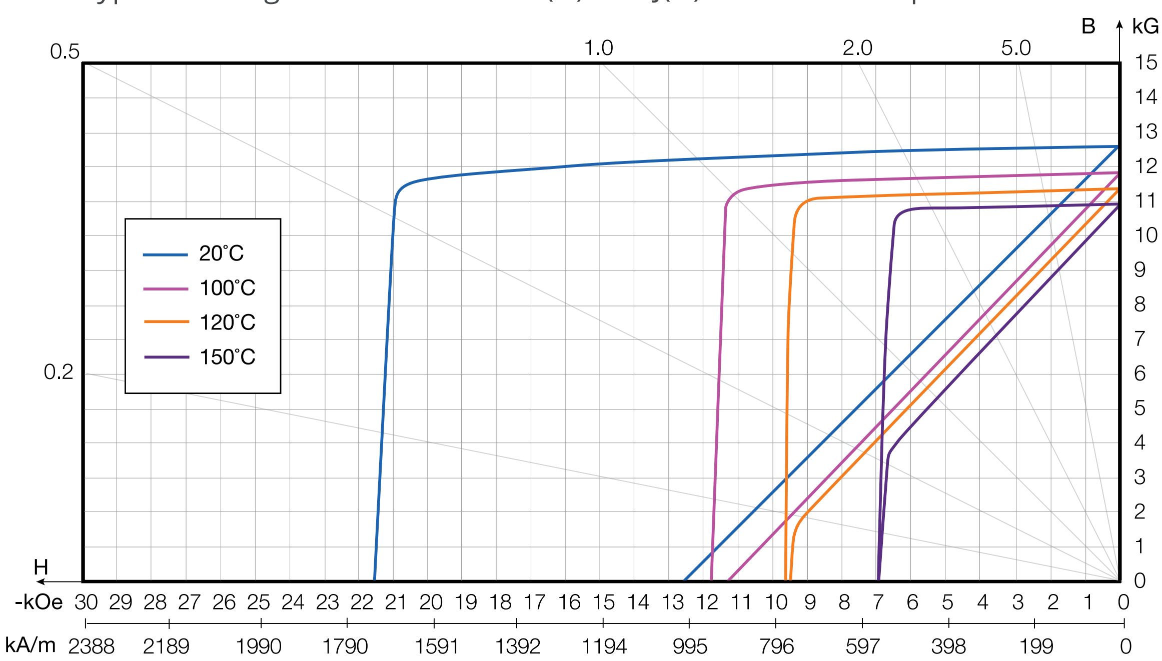
Curves for other material grades are available upon request.

Neodymium 4020

Magnetic characteristics

Br (kG)	12.5~12.8	MAX OP TEMP 150˚C/302˚F OPERATING SLOPE OF 1	
Hci (kOe)	≥20		
Hc (kOe)	≥11.8	Tc of Br (%/˚C)	-0.12
BHmax (MGOe)	38~41	Tc of HCi (%/˚C)	-0.70

Typical demagnetization curves B(H) and J(H) at various temperatures:



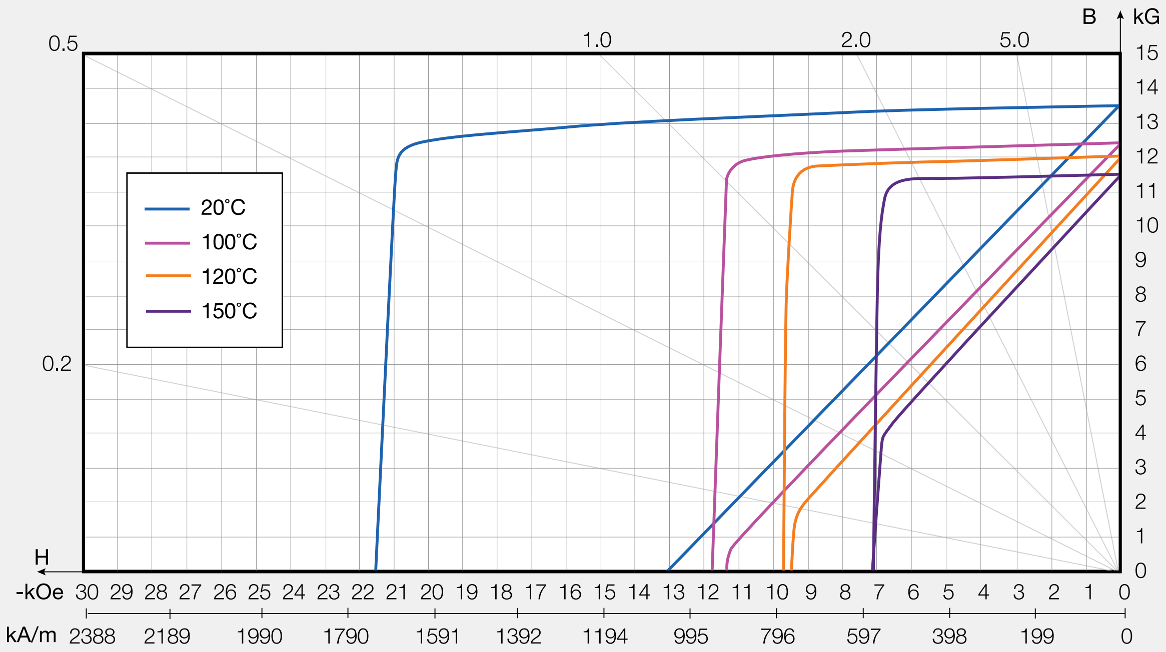
Curves for other material grades are available upon request.

Neodymium 4520

Magnetic characteristics

Br (kG)	13.2~13.7	MAX OP TEMP 140˚C/284˚F OPERATING SLOPE OF 1	
Hci (kOe)	≥20		
Hc (kOe)	≥12.5	Tc of Br (%/˚C)	-0.12
BHmax (MGOe)	43~46	Tc of Hci (%/˚C)	-0.70

Typical demagnetization curves B(H) and J(H) at various temperatures:



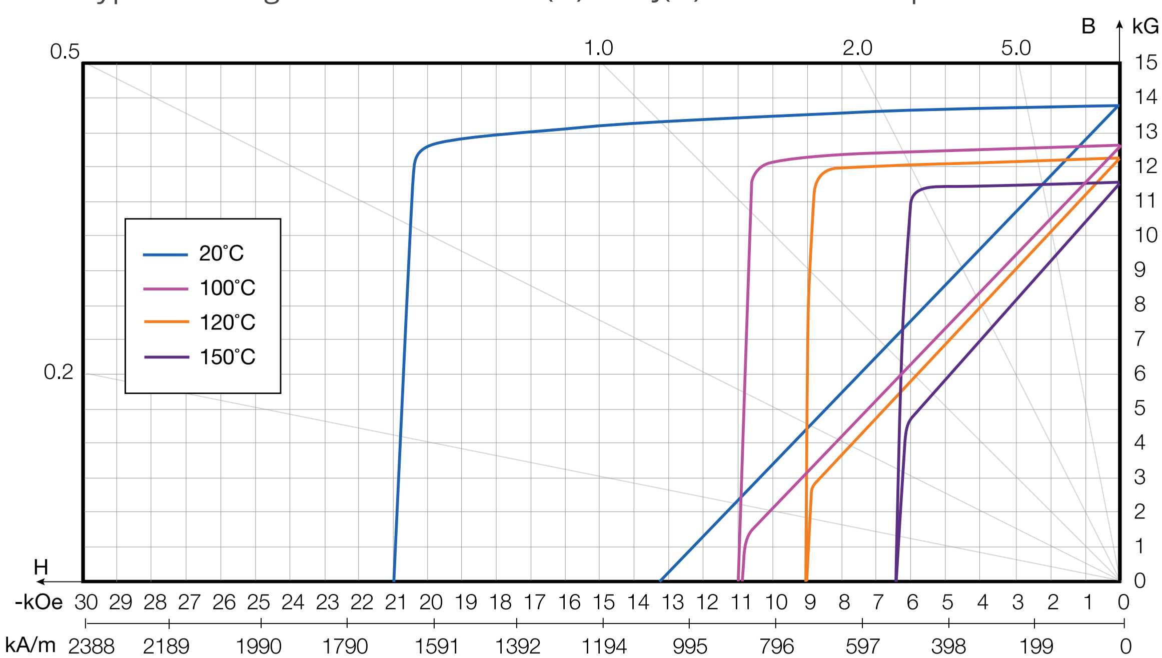
Curves for other material grades are available upon request.

Neodymium 4820

Magnetic characteristics

Br (kG)	13.6~14.2	MAX OP TEMP 130˚C/266˚F OPERATING SLOPE OF 1	
Hci (kOe)	≥20		
Hc (kOe)	≥12.9	Tc of Br (%/˚C)	-0.12
BHmax (MGOe)	45~49	Tc of HCi (%/˚C)	-0.70

Typical demagnetization curves B(H) and J(H) at various temperatures:



Curves for other material grades are available upon request.

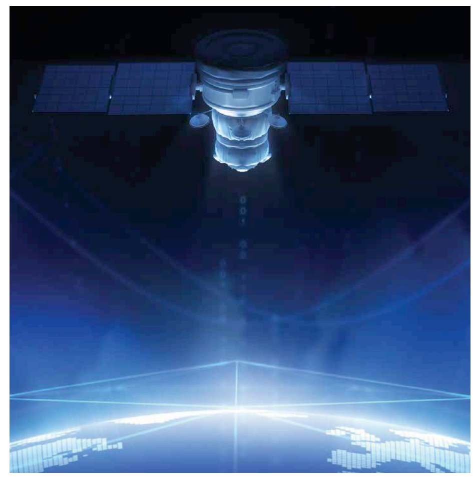
Samarium Cobalt

Samarium Cobalt (SmCo) permanent magnets are known for their high magnetic strength, exceptional temperature stability, and reliable performance. Since they rarely require coating to combat corrosion, they are more suitable for certain applications than Neodymium.

Samarium cobalt magnets are often used when a wide range of operating temperatures is expected or if temperature effects must be mitigated, as when high accuracy or highly stable performance is desired. A potential challenge is their propensity to chip and crack, due to their brittle nature.

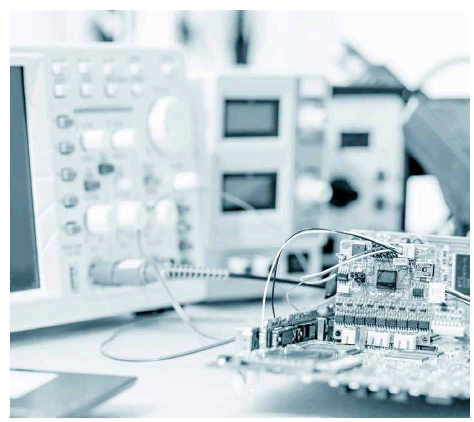
1:5 Alloy Material Characteristics

1:5 series SmCo provides an energy product between 16 and 23 MGOe and is made up of approximately 37% samarium and 63% cobalt. Considering an operating slope of one, a low coercivity grade 1:5 series may begin to experience permanent losses if heated above 482°F (250°C). Special (non-catalog versions) of high coercivity grade 1:5 SmCo can function at temperatures in excess of 752°F (400°C) with little to no irreversible loss. Contact us for more information. SmCo 1:5 magnets require lower field strengths than 2:17 materials to magnetize. In some instances, 1:5 material may be magnetized with multiple poles.



2:17 Alloy Material Characteristics

2:17 series SmCo provides an energy product between 24 and 33 MGOe and is composed of about 25% samarium, 5% copper, 18% iron and 2% hafnium or zirconium, with the remainder being cobalt. Considering an operating slope of one, a low coercivity grade 2:17 series SmCo may begin to experience permanent losses if heated above 482°F (250°C). High coercivity grade 2:17 SmCo can function at temperatures in excess of 932°F (500°C) with little to no irreversible loss. Specialized grades (not published in this catalog) are available for even higher temperature requirements. SmCo 2:17 requires a higher magnetizing field when compared to SmCo 1:5. With the appropriate magnetizing fixture, multipole magnetization may be possible.



Coatings

Samarium Cobalt magnets are inherently corrosion resistant and are therefore rarely coated for increased corrosion protection. Small SmCo magnets may be coated or plated to mitigate chip or crack formation. Also, un-ground sintered SmCo material can exhibit a visible level of surface roughness, so a coating or plating may be used to aid in cleaning the part in applications where this is a requirement. When a surface treatment is required, the coatings used for NdFeB magnets can be used on SmCo material. See page 8 for coatings data.

Applications

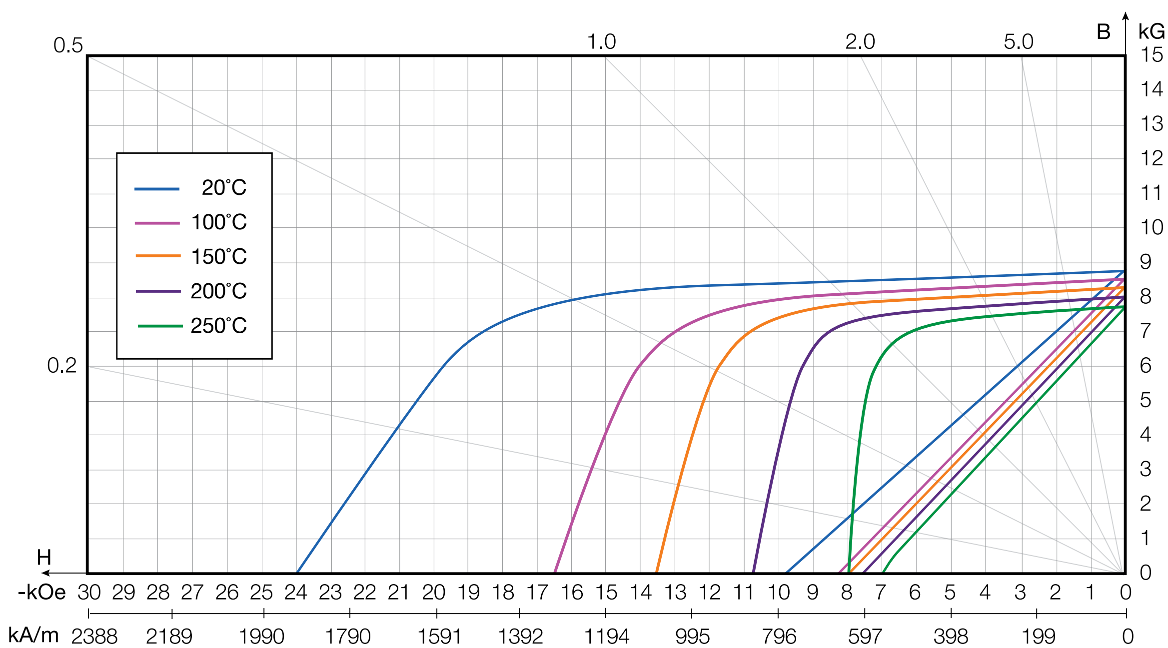
Samarium Cobalt magnets are used in a wide range of applications, including high performance permanent magnet motors, medical instruments, magnetic couplings, magnetic bearings, gyroscopes, accelerometers, voice coil motors, particle accelerators, sputtering deposition, Halbach arrays, magnetic separation devices, speakers, microphones, undulators, wigglers, particle beam focusing devices, and many others.

Samarium Cobalt 1:5 Grade 18

Magnetic characteristics

Br (kG)	8.4~8.9	MAX OP TEMP 250˚C/482˚F OPERATING SLOPE OF 1	
Hci (kOe)	≥23		
Hc (kOe)	8.1~8.6	Tc of Br (%/˚C)	-0.040
BHmax (MGOe)	17-19	Tc of Hci (%/˚C)	-0.30

Typical demagnetization curves B(H) and J(H) at various temperatures:

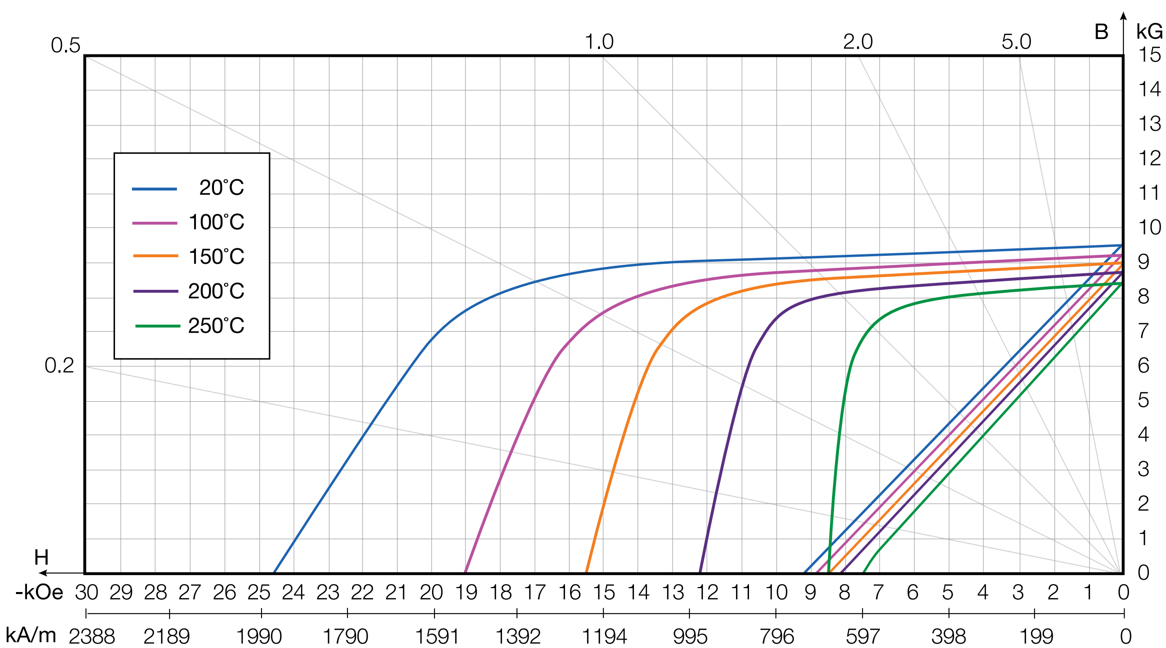


Samarium Cobalt 1:5 Grade 22

Magnetic characteristics

Br (kG)	9.2~9.6	MAX OP TEMP 250˚C/482˚F OPERATING SLOPE OF 1	
Hci (kOe)	≥23		
Hc (kOe)	8.6~9.4	Tc of Br (%/˚C)	-0.045
BHmax (MGOe)	21~23	Tc of Hci (%/˚C)	-0.30

Typical demagnetization curves B(H) and J(H) at various temperatures:

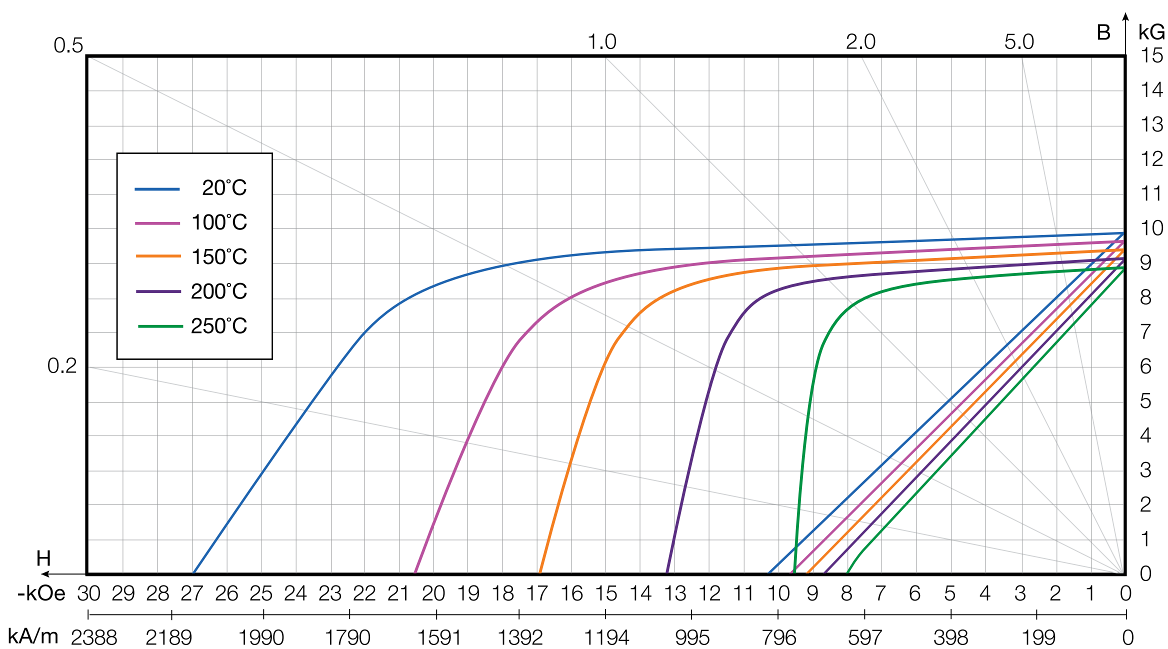


Samarium Cobalt 2:17 Grade 2425

Magnetic characteristics

Br (kG)	9.5~10.2	MAX OP TEMP 350˚C/662˚F OPERATING SLOPE OF 1	
Hci (kOe)	≥ 25		
Hc (kOe)	8.7~9.6	Tc of Br (%/˚C)	-0.025
BHmax (MGOe)	22-24	Tc of Hci (%/˚C)	-0.20

Typical demagnetization curves B(H) and J(H) at various temperatures:



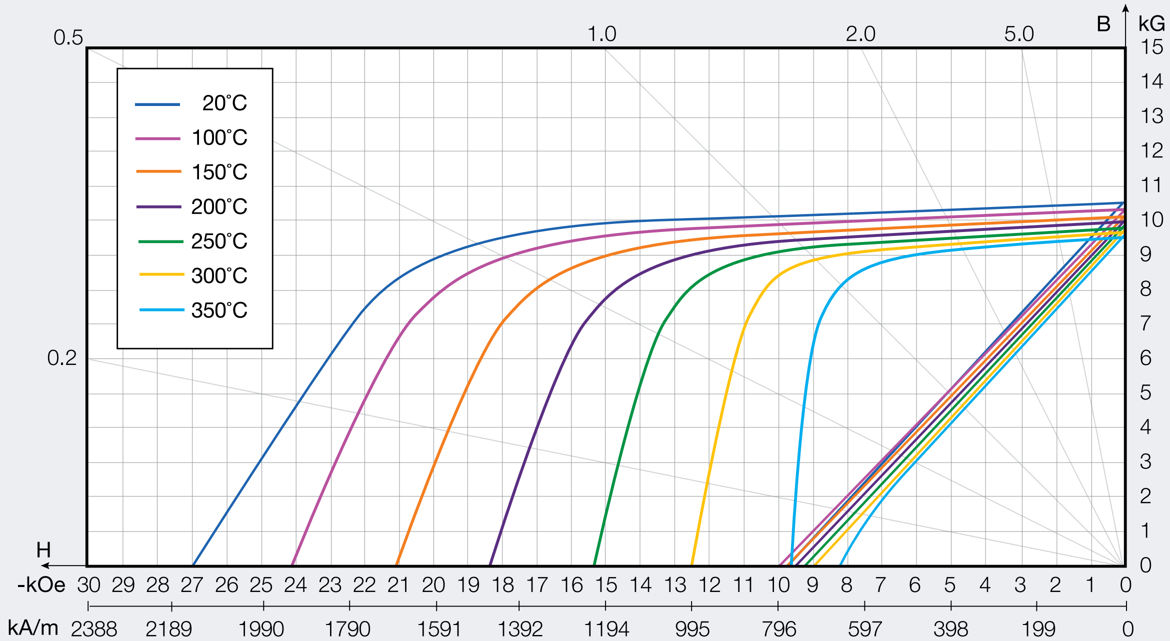
Curves for other material grades are available upon request.

Samarium Cobalt 2:17 Grade 2825

Magnetic characteristics

Br (kG)	10.3~10.8	MAX OP TEMP OPERATING SLOPE OF 1	350˚C662˚F
Hci (kOe)	≥ 25		
Hc (kOe)	9.5~10.2	Tc of Br (%/˚C)	-0.035
BHmax (MGOe)	26-28	Tc of Hci (%/˚C)	-0.20

Typical demagnetization curves B(H) and J(H) at various temperatures:



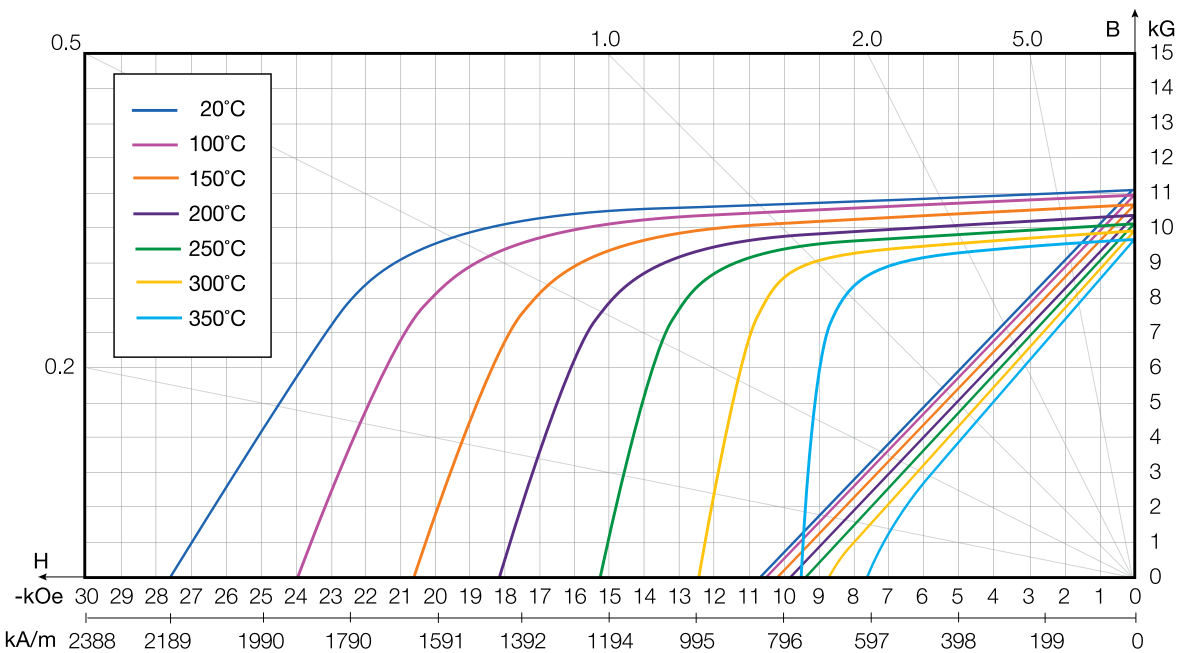
Curves for other material grades are available upon request.

Samarium Cobalt 2:17 Grade 3225

Magnetic characteristics

Br (kG)	11.0~11.3	MAX OP TEMP 350˚C/662˚F OPERATING SLOPE OF 1	
Hci (kOe)	≥ 25		
Hc (kOe)	10.2~10.7	Tc of Br (%/˚C)	-0.035
BHmax (MGOe)	29-32	Tc of Hci (%/˚C)	-0.20

Typical demagnetization curves B(H) and J(H) at various temperatures:



Curves for other material grades are available upon request.

Ceramic

Ceramic magnets (also known as ferrite magnets) were developed in the 1960s as a low cost alternative to metallic magnets. These magnets are the first choice for most types of DC motors, magnetic separators, magnetic resonance imaging and automotive sensors.

Ceramic magnets have won wide acceptance due to their corrosion and demagnetization resistance, and low price per pound. However, their hard, brittle quality and low energy will exclude them from some applications.

Machining and Tolerances

Machining must be performed with a diamond wheel, preferably prior to magnetization. Standard tolerances are +/-.005" for ground dimensions and +/- 2% of feature size for sintered dimensions. Due to their brittle nature these magnets will not withstand impact or flexing. They are also not recommended as structural components in assemblies. Ceramic magnets are chemically inert non-conductors, which is a benefit in many applications but eliminates the use of the EDM process to produce samples or special shapes.

Temperature Constraints

Due to Ceramic's positive temperature coefficient of Hci, high temperatures are not generally a major concern with respect to irreversible magnetic loss. However, low temperatures pose a much greater risk for permanent demagnetization. A ceramic 5 grade with a permeance coefficient of 1 will start to experience permanent losses below -20°C.

Magnetization

Isotropic ceramic grades can be magnetized in any direction, while anisotropic grades have a preferred direction of magnetization and will only meet their full magnetic potential when magnetized along the "easy axis".

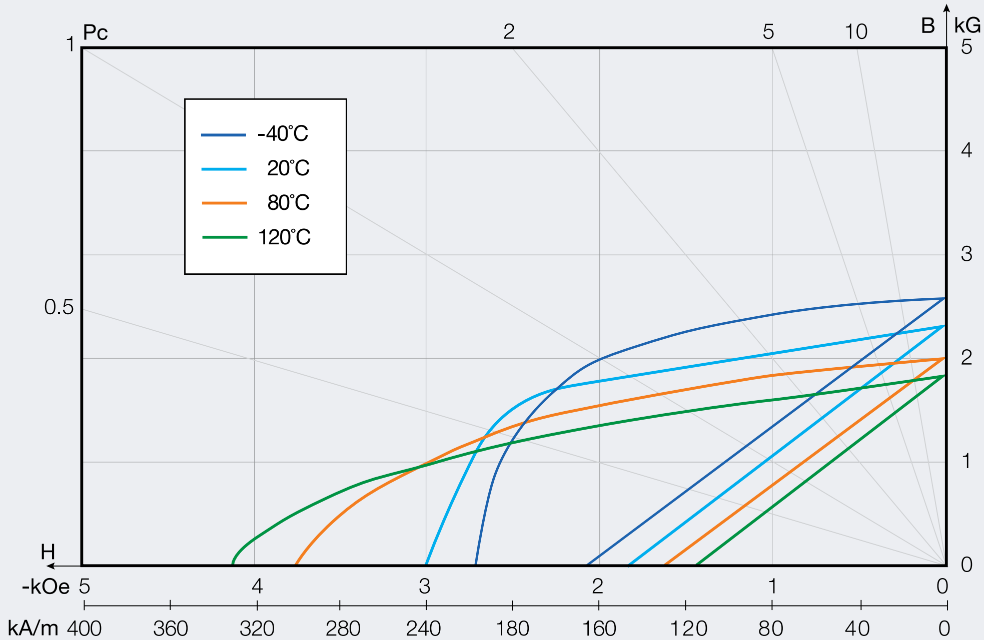
Coatings

Made from iron oxides, Ceramic magnets are the most naturally corrosion-resistant sintered magnets available. Exposure to water, salt water, solvents, oils, and even weak acids will have a negligible impact on their performance. Coatings may be applied for cosmetic reasons or to help prevent the transfer of ferrite dust. Because Ceramic magnets are non-conductive they can't be electroplated like NdFeB, SmCo, and Alnico materials. However, there are many electroless platings available. Common surface treatments for Ceramic ferrite magnets include paint, powder coat, parylene, phenolic resin, Teflon, silicone, and EPDM rubber. Contact us for more details about these coating options.

Ceramic 1

Magnetic characteristics
& typical demagnetization curves

Br (G)	2,300	MAX OP TEMP	399˚C/750˚F
Hci (Oe)	3,000	OPERATING SLOPE OF 1	
Hc (Oe)	1,850	Tc of Br (%/˚C)	-0.2
BHmax (MGOe)	1.0	Tc of Hci (%/˚C)	0.2-0.5

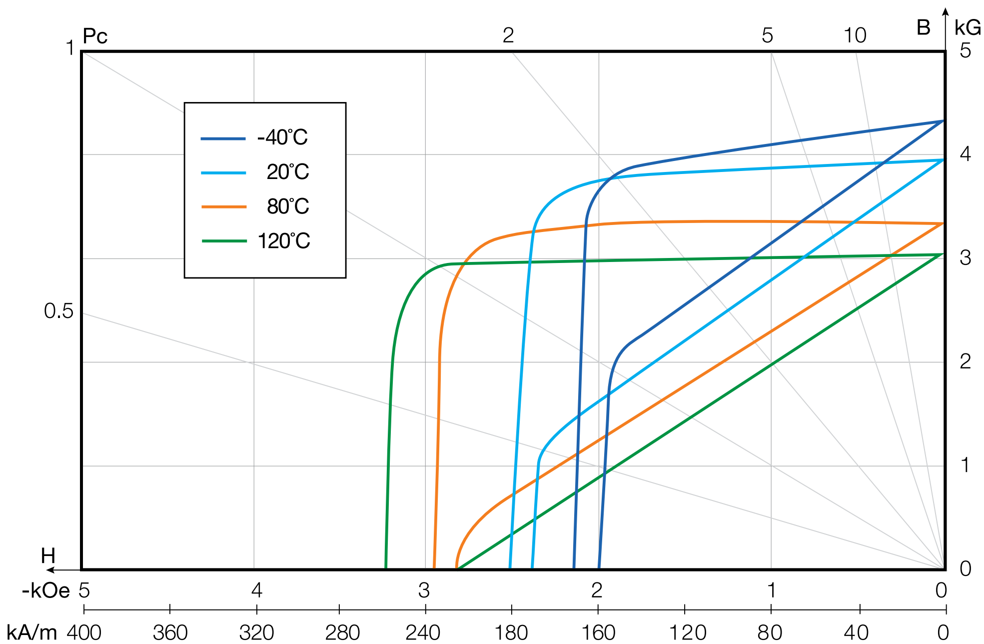


Ceramic 5

Magnetic characteristics

Br (G)	3,950	MAX OP TEMP 399˚C/750˚F OPERATING SLOPE OF 1	
Hci (Oe)	2,500		
Hc (Oe)	2,400	Tc of Br (%/˚C)	-0.2
BHmax (MGOe)	3.4	Tc of Hci (%/˚C)	0.2-0.5

Typical demagnetization curves B(H) and J(H) at various temperatures:

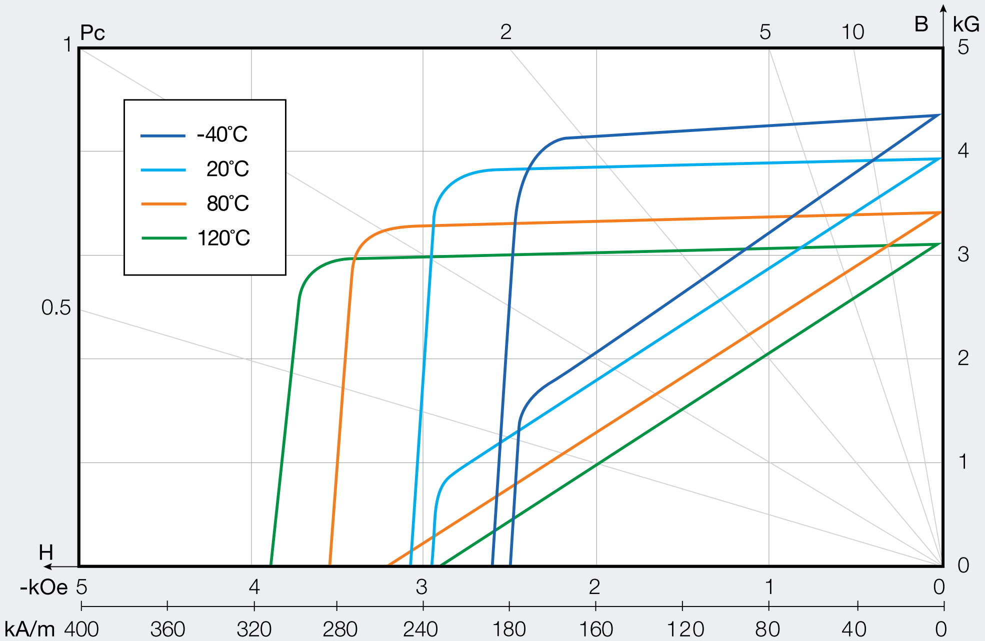


Ceramic 8a

Magnetic characteristics

Br (G)	3,900	MAX OP TEMP 399˚C/750˚F OPERATING SLOPE OF 1	
Hci (Oe)	3,050		
Hc (Oe)	2,950	Tc of Br (%/˚C)	-0.2
BHmax (MGOe)	3.5	Tc of Hci (%/˚C)	0.2-0.5

Typical demagnetization curves B(H) and J(H) at various temperatures:



Alnico characteristics and curves

Most Alnico magnets are manufactured using typical foundry casting techniques, where molten alloy is poured into sand molds.

Magnets weighing one ounce or less are produced using press and sinter techniques. Sintered Alnico magnets have features that make them particularly effective in small precision devices. Sintered magnets are available in both isotropic and anisotropic form, with a wide range of unit properties, and can be sintered with small holes and intricate shapes. Their magnetic properties are similar but often slightly lower than cast magnets of equivalent grade.

Surface imperfections such as cracks and porosity are common in Alnico magnets and do not normally affect magnet performance.

Grinding and Tolerances

Adams provides in-house cutting and grinding to meet your application requirements.

Alnico is hard and brittle (45-55 Rockwell C), and is not suitable for drilling, tapping or conventional machining operations. Close tolerances are attained by abrasive grinding and cutting.

Coatings

While Alnico is intrinsically corrosion resistant, it does contain some free iron and over time surface corrosion may propagate. Although not often plated or coated for corrosion protection, the most common surface treatment we see for Alnico is red epoxy paint, as can be observed on most horseshoe magnets.

Temperature Constraints and Magnetization

Alnico has the best temperature coefficient of any but the most advanced commercial magnet material, providing for excellent stability over a wide temperature range. A properly designed circuit using Alnico magnets will have a stable flux output during temperature fluctuations.

Although Alnico displays considerable residual induction, it conversely exhibits among the lowest coercivity of any magnetic material. A consequence of low coercivity is sensitivity to demagnetizing effects caused by external magnetic fields, shock, and application temperatures.

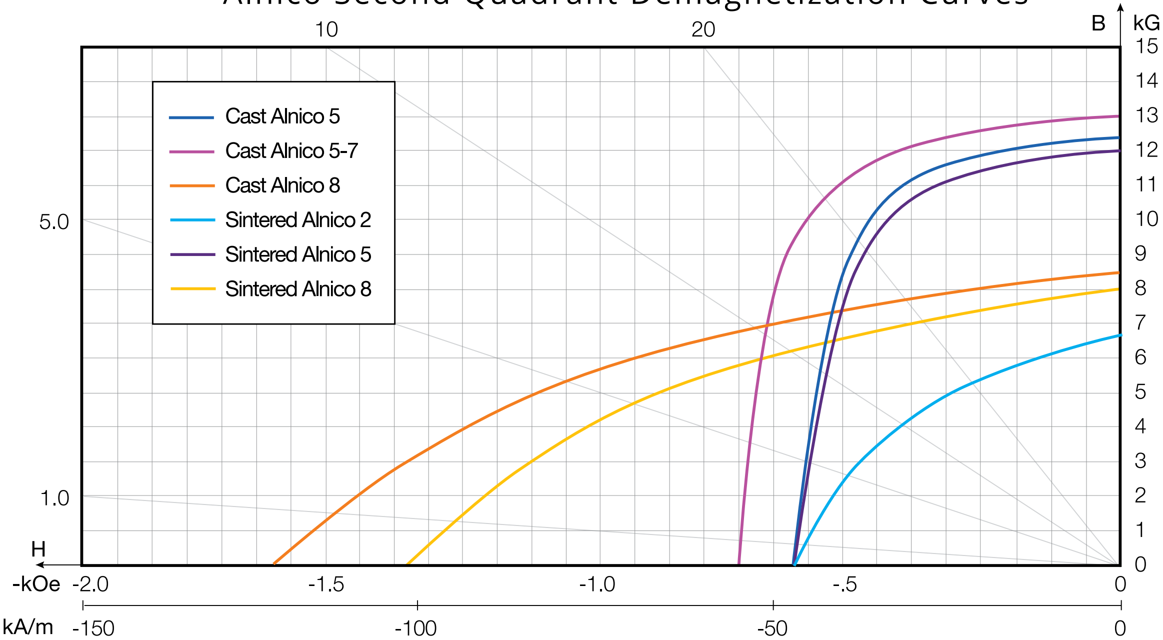
For critical applications, Alnico magnets can be magnetically stabilized to minimize these effects, and can be partially demagnetized if like poles of magnets are brought together. Placing individual magnets in contact with ferrous materials can also partially demagnetize them.

Typical open circuit Alnico 5 applications require a long magnetic length to pole surface ratio (usually 4:1 or greater) to ensure good magnetic performance.

Care must be taken in handling magnetized magnets.

Check with Adams' technical staff to confirm the best ratio for your application.

Alnico Second Quadrant Demagnetization Curves



Added Value Services

Magnetic Modeling

Adams uses the most up-to-date magnetic modeling software that can accurately predict the performance of virtually any type of magnet, magnet assembly or electromagnet.

It can predict magnetic fields from sensor magnets, pull forces from holding assemblies, torque from torque assemblies and electromagnet performance.

Surface Protection: Coating Rare Earth Magnets

Corrosion resistant coatings can be applied to magnets directly after production and cleaning, and prior to magnetization. Standard coatings include nickel, epoxy and zinc spray coatings. Surface protection may also be applied to magnets in the finished product system. Contact Adams applications support to help you select the best coating for your application.

Magnet Fastening

The majority of magnets are assembled into magnet systems using adhesives. Such construction may require the adhesion of multiple magnets to one another or to support parts. But before doing so, several factors must be considered to assure the effective performance of the magnet, the adhesive and the resulting bond. These include the chemical and physical properties of the magnets and the surfaces to which they are affixed. Detailed coverage of all these factors, along with some adhesives to try, is covered in our white paper *Gluing Magnets*, which can be downloaded from our website.

Value Added Assemblies

At Adams we look beyond the magnet to the application, to drive cost savings opportunities for our customers. Our team of technical experts is ready to participate in KAIZEN events, LEAN activities, and other Value Analysis/Value Engineering (VAVE) programs. With foreign and domestic assembly operations, and years of in-depth magnet experience, you can rely on Adams Magnetic Products to be your partner in all things magnetic.

From the simple to the complex, let our team of experts evaluate your assembly process to see if outsourcing is a viable option. We offer assemblies of ferrous and non-ferrous materials, large to small and everything in between. From simple round base, channel, and sandwich assemblies, to highly technical electronic and electromechanical designs, Adams has the knowledge, expertise and procedures in place to meet even the most stringent of quality standards.

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