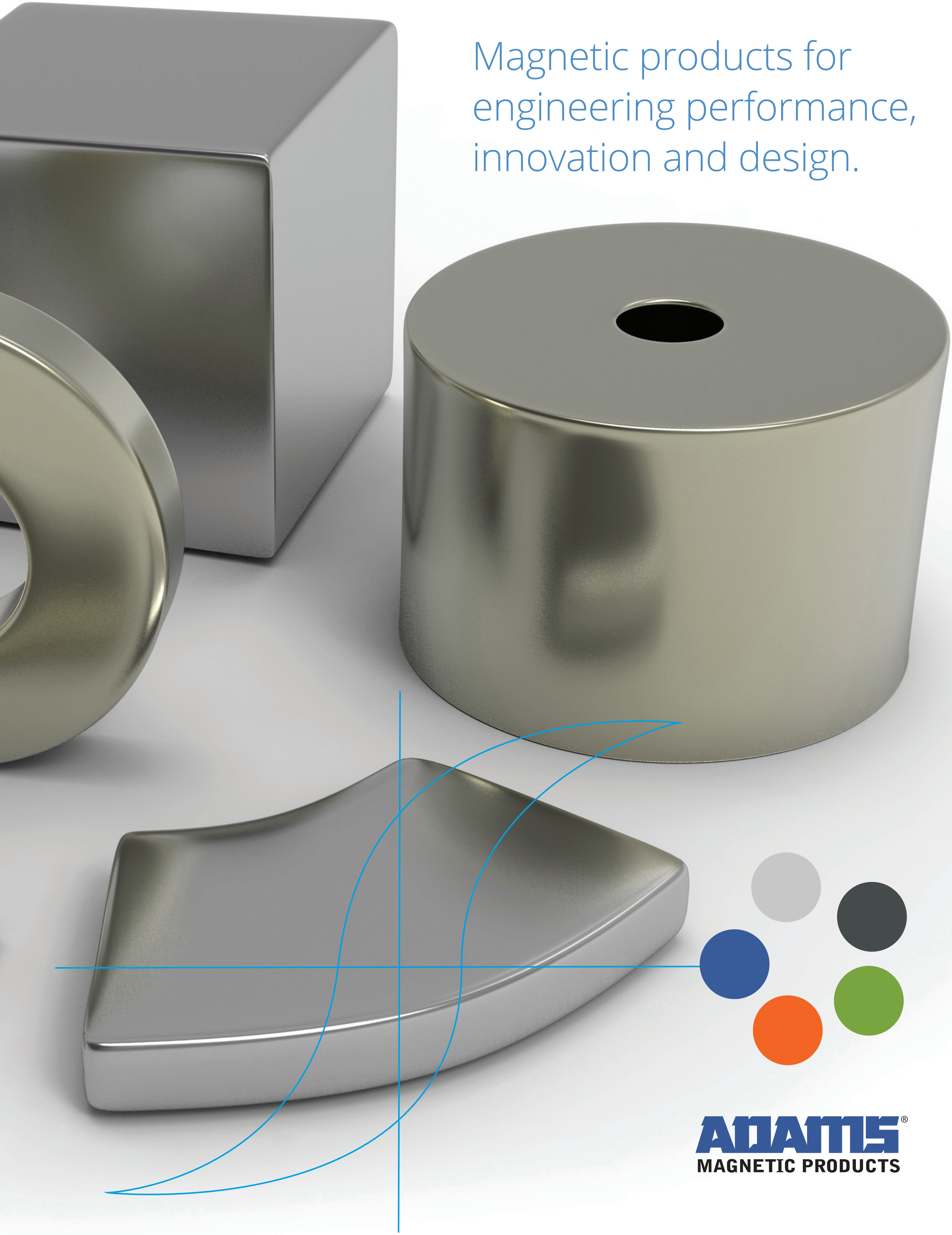
Magnetic products for engineering performance, innovation and design.



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 9001:2008 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

Magnet materials overview

Alnico

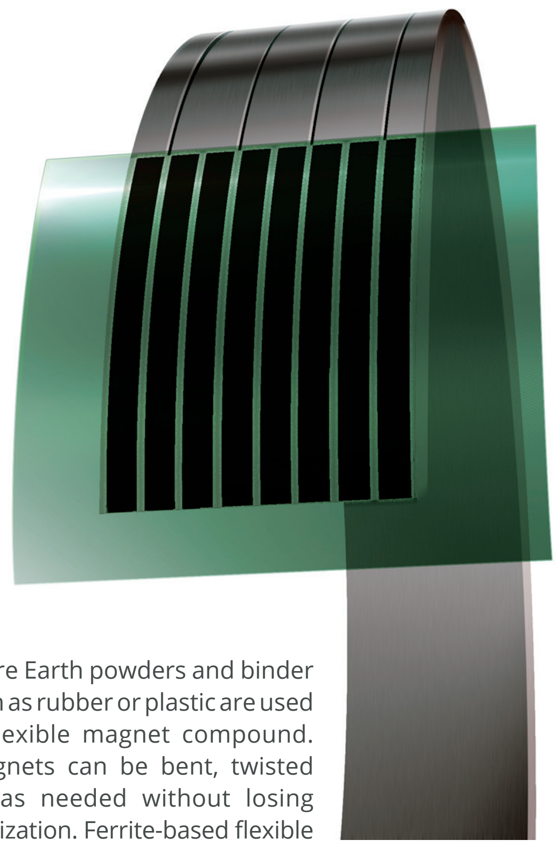
Temperature stability is one of the key benefits of Alnico magnets, which have been a mainstay of the industry since the 1930s, Composed of aluminum, nickel, and cobalt, and available in both cast and sintered forms, Alnico can withstand temperatures up to 500°C with no magnetization loss. Additional benefits include ease of demagnetization and high corrosion resistance. Alnico magnets exhibit high Br, but low Hc, and BHmax in the 5 MGOe range. Their energy product range is approximately 1.4-11 MGOe.

Neodymium Iron Boron

Among commercial magnet materials, the rare earth Neodymium Iron Boron magnet is the most powerful in the marketplace. Available in both sintered and bonded forms, this class of Rare Earth material possesses the highest Br, relatively high Hc and high BHmax. In many cases it is a more economical alternative to Samarium Cobalt, but is only suitable for certain applications because of its temperature sensitivity (maximum functional temperature: 250°C) and susceptibility to oxidation. Neodymium iron boron has an approximate energy product range of 10-53 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 so commonly found in everyday consumer applications. Many automotive small motor applications are sintered ferrite magnets. 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

Ferrite or Rare Earth powders and binder systems such as rubber or plastic are used to form a flexible magnet compound. Flexible magnets can be bent, twisted and coiled as needed without losing their magnetization. Ferrite-based flexible magnets are available from 0.6-1.6 MGOe, while those with Rare Earth-based materials can reach 6 MGOe. Grading varies by composition.

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): A term 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.

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.

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.

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.

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.

Grade	Residual Induction Br-Gs	Intrinsic Coercive Hci-Oe	Coercive Force Hc-Oe	BHmax Energy MGOe	Max. Operating Temp. in °C/°F at an Operating Slope of 1	TC of Br % /°C	TC of Hci % /°C
ALNICO MATERIAL							
Sintered Alnico 2	5000	600	600	1.50	450°C/840°F	-0.014	
Sintered Alnico 5	12000	630	600	4.25	450°C/840°F	-0.016	
Sintered Alnico 8	8000	1690	1500	4.75	450°C/840°F	-0.02	
Cast Alnico 2	7000	580	550	1.50	550°C/1020°F	-0.02	
Cast Alnico 3	6000	550	550	1.25	550°C/1020°F	-0.02	
Cast Alnico 5	12300	640	600	5.00	550°C/1020°F	-0.02	
Cast Alnico 5-7	13000	740	720	7.00	550°C/1020°F	-0.02	
Cast Alnico 8	8500	1860	1650	5.50	550°C/1020°F	-0.02	
Cast Alnico 9	10800	1500	1500	10.00	550°C/1020°F	-0.02	
	above values are nominal properties						
CERAMIC MATERIAL							
Ceramic 1	≥2300	≥3000	≥1860	≥1.0	399°C/750°F	-0.2	0.2~0.5
Ceramic 5	≥3850	≥2500	≥2400	≥3.4	399°C/750°F	-0.2	0.2~0.5
Ceramic 8a	≥3850	≥3050	≥2950	≥3.5	399°C/750°F	-0.2	0.2~0.5
Ceramic 8b	≥4200	≥2580	≥2510	≥4.1	399°C/750°F	-0.2	0.2~0.5
Ceramic 8c	≥4300	≥2730	≥2700	≥4.2	399°C/750°F	-0.2	0.2~0.5
SAMARIUM COBALT MATERIAL							
1.5 SERIES							
SmCo 18	8,400~8,900	≥23,000	8,100~8,600	17-19	250°C/482°F	-0.040	-0.30
SmCo 20	8,900~9,300	≥23,000	8,600~9,100	19-21	250°C/482°F	-0.045	-0.30
SmCo 22	9,200~9,600	≥23,000	8,600~9,400	21-23	250°C/482°F	-0.045	-0.30
SmCo 24	9,600~10,000	≥23,000	9,300~9,800	22-24	250°C/482°F	-0.045	-0.30
SmCoLTC10	6,200~6,600	≥23,000	6,100~6,500	9.5-11	300°C/572°F	Temp.	Br%/°C
						20-100°C	+0.0156
						100-200°C	+0.0087
						200-300°C	+0.0007
2.17 SERIES							
SmCo2412	9500~10,200	8k/12k	6,800~9,000	22-24	250°C/482°F	-0.025	-0.20
SmCo2612	10,200~10,500	8k/12k	6,800~9,400	24-26	250°C/482°F	-0.035	-0.20
SmCo2812	10,300~10,800	8k/12k	6,800~9,600	26-28	250°C/482°F	-0.035	-0.20
SmCo3012	10,800~11,500	8k/12k	6,800~10,000	28-30	250°C/482°F	-0.035	-0.20
SmCo3212	11,000~11,500	8k/12k	6,800~10,200	29-32	250°C/482°F	-0.035	-0.20
SmCo2616	10,200~10,500	12k-18k	8,500~9,800	24-26	300°C/572°F	-0.035	-0.20
SmCo2816	10,300~10,800	12k-18k	8,500~10,000	26-28	300°C/572°F	-0.035	-0.20
SmCo3016	10,800~11,000	12k-18k	8,500~10,500	28-30	300°C/572°F	-0.035	-0.20
SmCo3216	11,000~11,300	12k-18k	8,500~10,600	29-32	300°C/572°F	-0.035	-0.20
SmCo2218	9300~9,700	≥ 18,000	8,500~9,300	20-23	300°C/572°F	-0.020	-0.20
SmCo2418	9500~10,200	≥ 18,000	8,700~9,600	22-24	300°C/572°F	-0.025	-0.20
SmCo2618	10,200~10,500	≥ 18,000	9,400~10,000	24-26	300°C/572°F	-0.030	-0.20
SmCo2818	10,300~10,800	≥ 18,000	9,500~10,200	26-28	300°C/572°F	-0.035	-0.20
SmCo3018	10,800~11,500	≥ 18,000	9,900~10,500	28-30	300°C/572°F	-0.035	-0.20
SmCo3218	11,000~11,500	≥ 18,000	10,200~10,700	29-32	300°C/572°F	-0.035	-0.20
SmCo2425	9500~10,200	≥ 25,000	8,700~9,600	22-24	350°C/662°F	-0.025	-0.20
SmCo2625	10,200~10,500	≥ 25,000	9,400~10,000	24-26	350°C/662°F	-0.030	-0.20
SmCo2825	10,300~10,800	≥ 25,000	9,500~10,200	26-28	350°C/662°F	-0.035	-0.20
SmCo3025	10,800~11,000	≥ 25,000	9,900~10,500	28-30	350°C/662°F	-0.035	-0.20
SmCo3225	11,000~11,300	≥ 25,000	10,200~10,700	29-32	350°C/662°F	-0.035	-0.20
SmCoLTC22	9400~9,800	15k-20k	8,400~9,000	22-24	300°C/572°F	Temp.	Br%/°C
						-50-25°C	+0.005
						20-100°C	-0.008
						100-200°C	-0.008
						200-300°C	-0.011

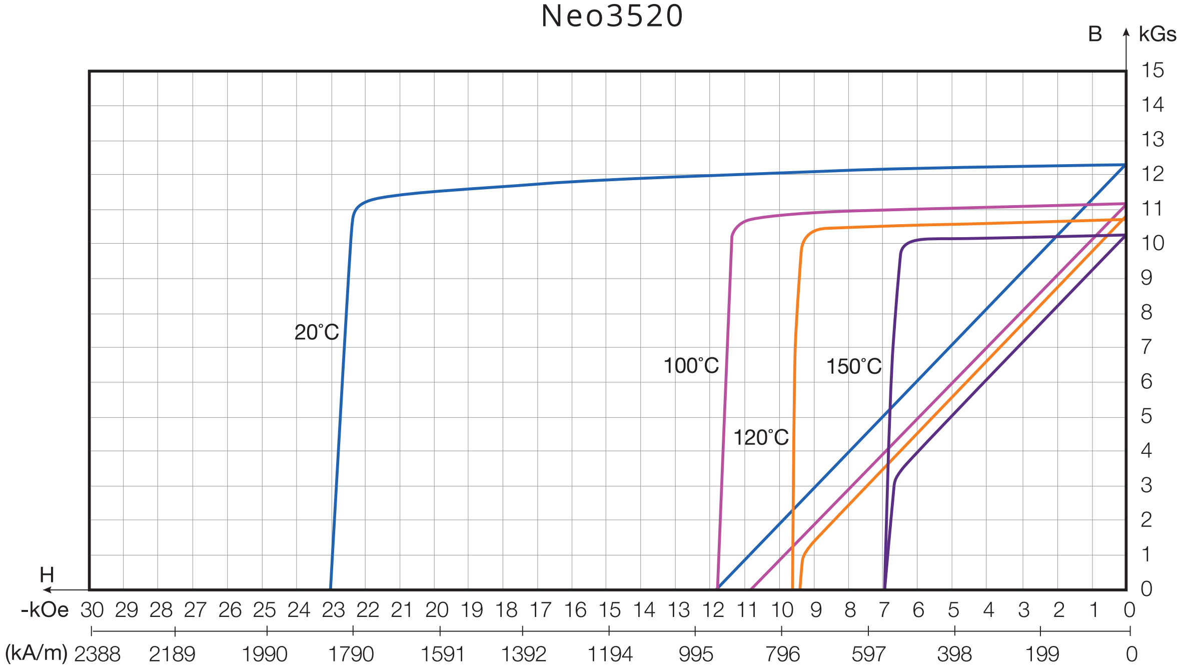
We offer additional grades with some properties added or improved upon request. Please consult our sales representative or technical personnel for more details.

Grade	Residual Induction Br-kGs	Intrinsic Coercive Hci-kOe	Coercive Force Hc-kOe	BHmax Energy MGOe	Max. Operating Temp. in °C/°F at an Operating Slope of 1	TC of Br % /°C	TC of HCi % /°C
NEODYMIUM MATERIAL							
Neo2817 (H)	10.4~10.9	≥17	9.6	25~28	120/248	-0.12	-0.70
Neo2820 (SH)	10.4~10.9	≥20	9.8	25~28	150/302	-0.12	-0.70
Neo2825 (UH)	10.2~10.8	≥25	9.6	25~28	108/356	-0.12	-0.70
Neo2830 (EH)	10.4~10.9	≥30	9.8	25~28	200/392	-0.12	-0.70
Neo2834 (AH)	10.2~10.9	≥34	9.8	25~29	220/428	-0.12	-0.70
Neo3012 (N)	10.8~11.3	≥12	10.0	28~31	80/176	-0.12	-0.70
Neo3014 (M)	10.8~11.3	≥14	10.0	28~31	100/212	-0.12	-0.70
Neo3017 (H)	10.8~11.3	≥17	10.0	28~31	120/248	-0.12	-0.70
Neo3020 (SH)	10.8~11.3	≥20	10.1	28~31	150/302	-0.12	-0.70
Neo3025 (UH)	10.8~11.3	≥25	10.2	28~31	180/356	-0.12	-0.70
Neo3030 (EH)	10.8~11.3	≥30	10.2	28~31	200/392	-0.12	-0.70
Neo3034 (AH)	10.7~11.3	≥34	10.5	27~31	220/428	-0.12	-0.70
Neo3312 (N)	11.3~11.7	≥12	10.5	31~34	80/176	-0.12	-0.70
Neo3314 (M)	11.3~11.7	≥14	10.5	31~34	100/212	-0.12	-0.70
Neo3317 (H)	11.3~11.7	≥17	10.5	31~34	120/248	-0.12	-0.70
Neo3320 (SH)	11.3~11.7	≥20	10.6	31~34	150/302	-0.12	-0.70
Neo3325 (UH)	11.3~11.7	≥25	10.7	31~34	180/356	-0.12	-0.70
Neo3330 (EH)	11.3~11.7	≥30	10.3	31~34	200/392	-0.12	-0.70
Neo3333 (AH)	11.1~11.7	≥33	10.5	30~34	220/428	-0.12	-0.70
Neo3512 (N)	11.7~12.2	≥12	10.9	33~36	80/176	-0.12	-0.70
Neo3514 (M)	11.7~12.2	≥14	10.9	33~36	100/212	-0.12	-0.70
Neo3517 (H)	11.7~12.2	≥17	10.9	33~36	120/248	-0.12	-0.70
Neo3520 (SH)	11.7~12.2	≥20	11.0	33~36	150/302	-0.12	-0.70
Neo3525 (UH)	11.7~12.2	≥25	10.8	33~36	180/356	-0.12	-0.70
Neo3530 (EH)	11.7~12.2	≥30	10.5	33~36	200/392	-0.12	-0.70
Neo3533 (AH)	11.7~12.2	≥33	10.5	33~36	220/428	-0.12	-0.70
Neo3812 (N)	12.2~12.5	≥12	11.3	36~39	80/176	-0.12	-0.70
Neo3814 (M)	12.2~12.5	≥14	11.3	36~39	100/212	-0.12	-0.70
Neo3817 (H)	12.2~12.5	≥17	11.3	36~39	120/248	-0.12	-0.70
Neo3820 (SH)	12.2~12.5	≥20	11.4	36~39	150/302	-0.12	-0.70
Neo3825 (UH)	12.2~12.5	≥25	11.0	36~39	180/356	-0.12	-0.70
Neo3830 (EH)	12.0~12.5	≥30	11.5	35~39	200/392	-0.12	-0.70
Neo4012 (N)	12.5~12.8	≥12	11.6	38~41	80/176	-0.12	-0.70
Neo4014 (M)	12.5~12.8	≥14	11.6	38~41	100/212	-0.12	-0.70
Neo4017 (H)	12.5~12.8	≥17	11.6	38~41	120/248	-0.12	-0.70
Neo4020 (SH)	12.5~12.8	≥20	11.8	38~41	150/302	-0.12	-0.70
Neo4025 (UH)	12.5~12.8	≥25	11.5	38~41	180/356	-0.12	-0.70
Neo4212 (N)	12.8~13.2	≥12	11.6	40~43	80/176	-0.12	-0.70
Neo4214 (M)	12.8~13.2	≥14	12.0	40~43	100/212	-0.12	-0.70
Neo4217 (H)	12.8~13.2	≥17	12.0	40~43	120/248	-0.12	-0.70
Neo4220 (SH)	12.8~13.2	≥20	12.2	40~43	150/302	-0.12	-0.70
Neo4225 (UH)	12.7~13.2	≥25	12.2	40~43	180/356	-0.12	-0.70
Neo4512 (N)	13.2~13.7	≥12	11.0	43~46	80/176	-0.12	-0.70
Neo4514 (M)	13.2~13.7	≥14	12.5	43~46	100/212	-0.12	-0.70
Neo4517 (H)	13.2~13.7	≥17	12.2	43~46	120/248	-0.12	-0.70
Neo4520 (SH)	13.2~13.7	≥20	12.3	43~46	150/302	-0.12	-0.70
Neo4812 (N)	13.7~14.2	≥12	11.2	45~49	80/176	-0.12	-0.70
Neo4814 (M)	13.6~14.2	≥14	12.8	45~49	100/212	-0.12	-0.70
Neo4817 (H)	13.6~14.2	≥17	12.9	45~49	120/248	-0.12	-0.70
Neo4820 (SH)	13.6~14.2	≥20	12.5	45~49	150/302	-0.12	-0.70
Neo5011 (N)	13.9~14.4	≥12	10.5	47~51	60/132	-0.12	-0.70
Neo5014 (M)	13.9~14.4	≥14	13.0	47~51	100/212	-0.12	-0.70
Neo5017 (H)	13.9~14.4	≥16	13.0	47~51	120/248	-0.12	-0.70
Neo5211 (N)	14.3~14.8	≥11	10.5	49~53	60/140	-0.12	-0.70

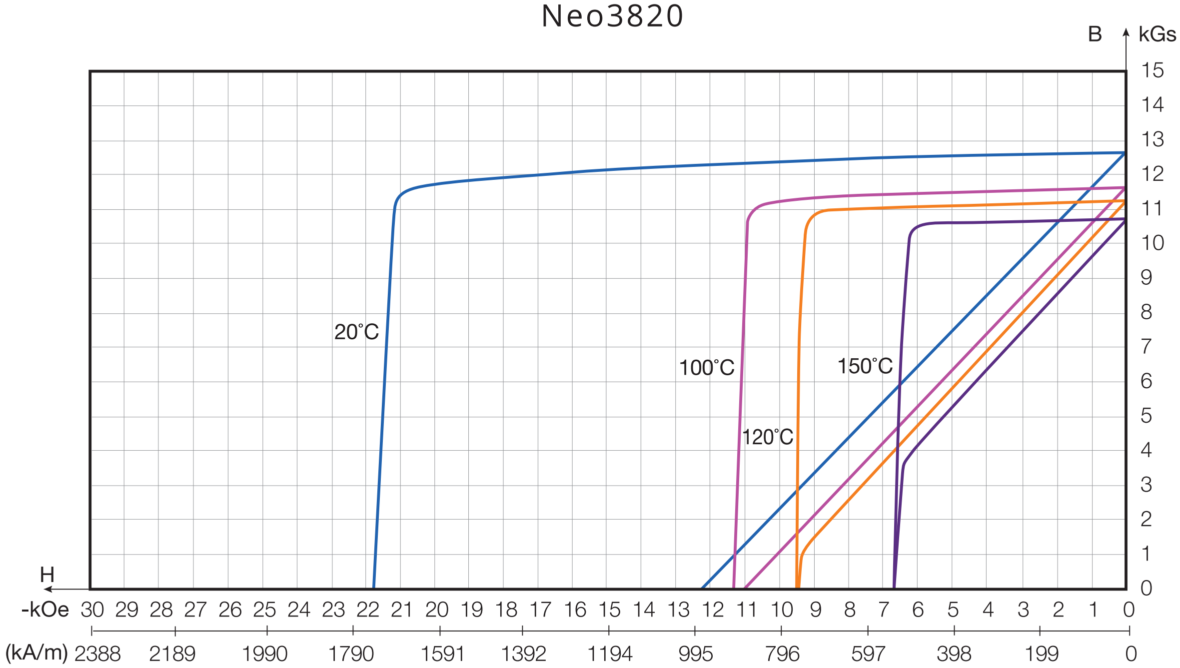
Neodymium demagnetization curves

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

Neo3520



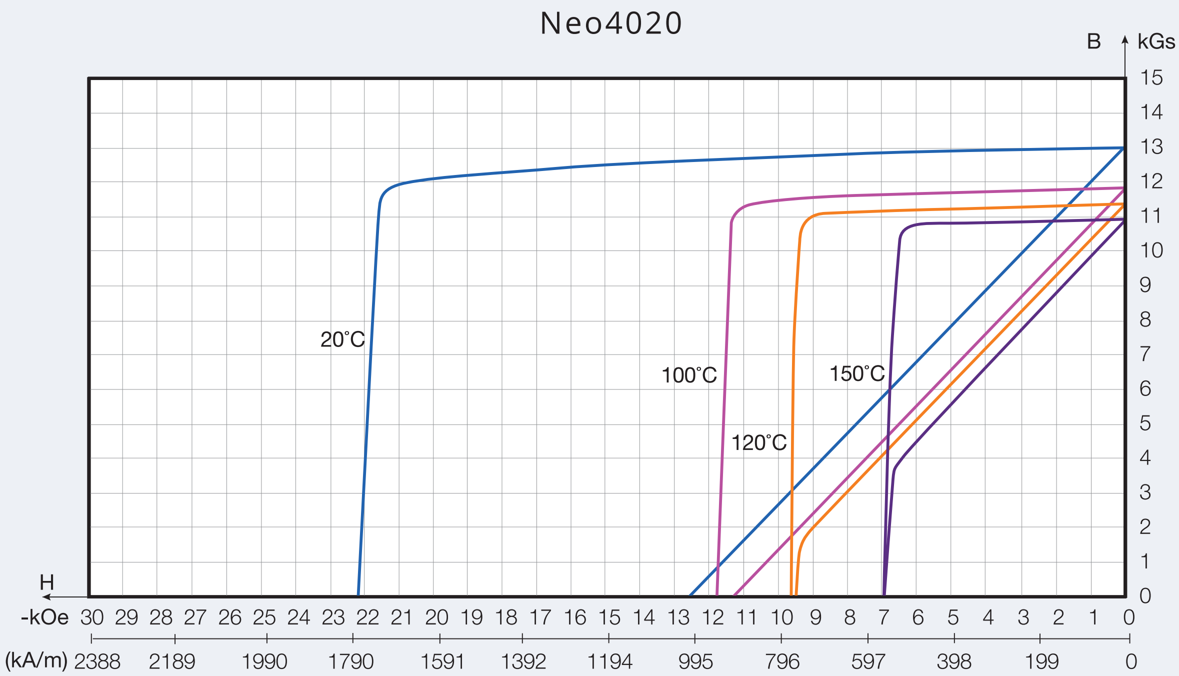
Neo3820

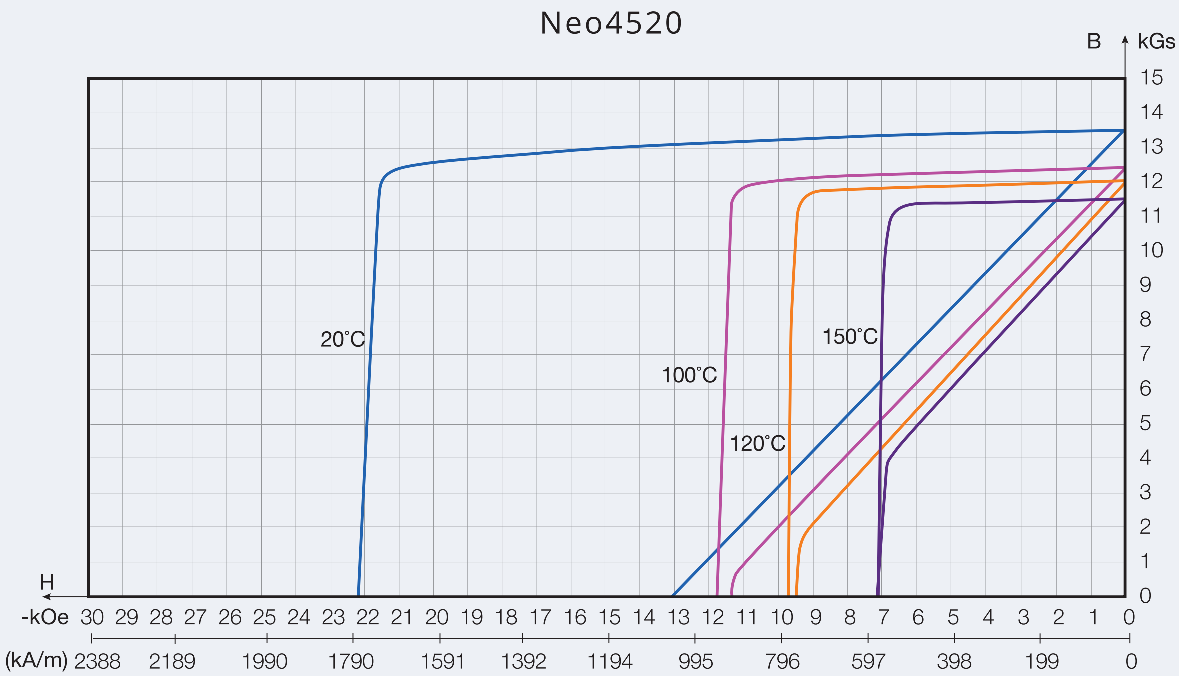


Curves for other material grades are available upon request.

Neodymium demagnetization curves

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



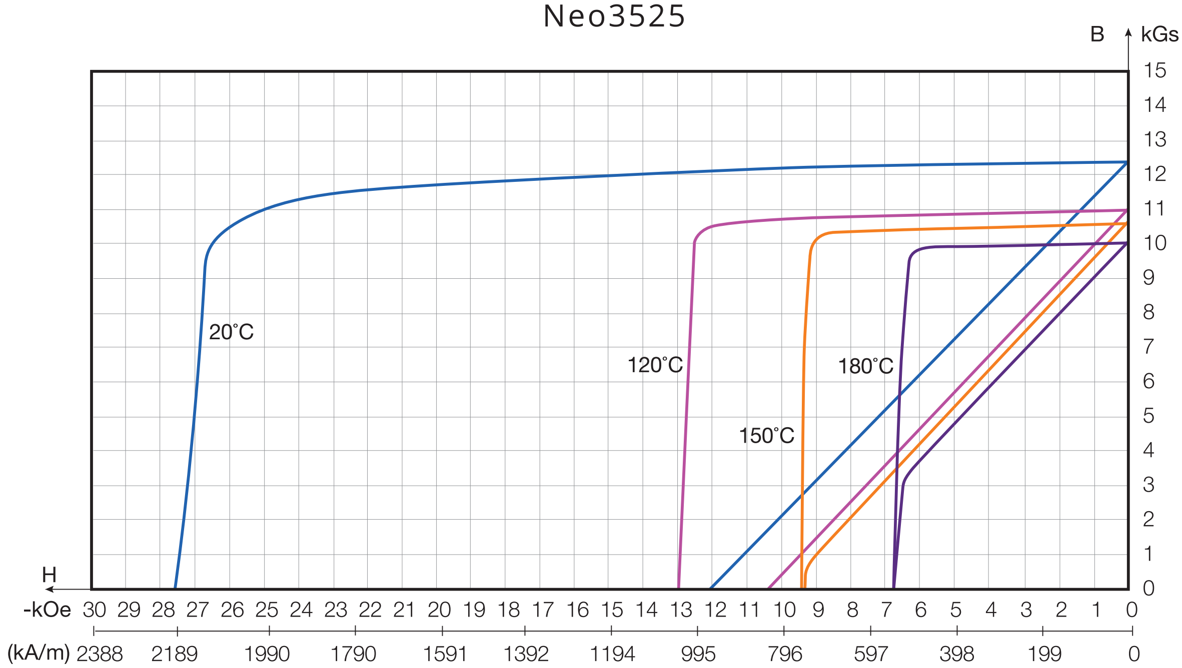


Curves for other material grades are available upon request.

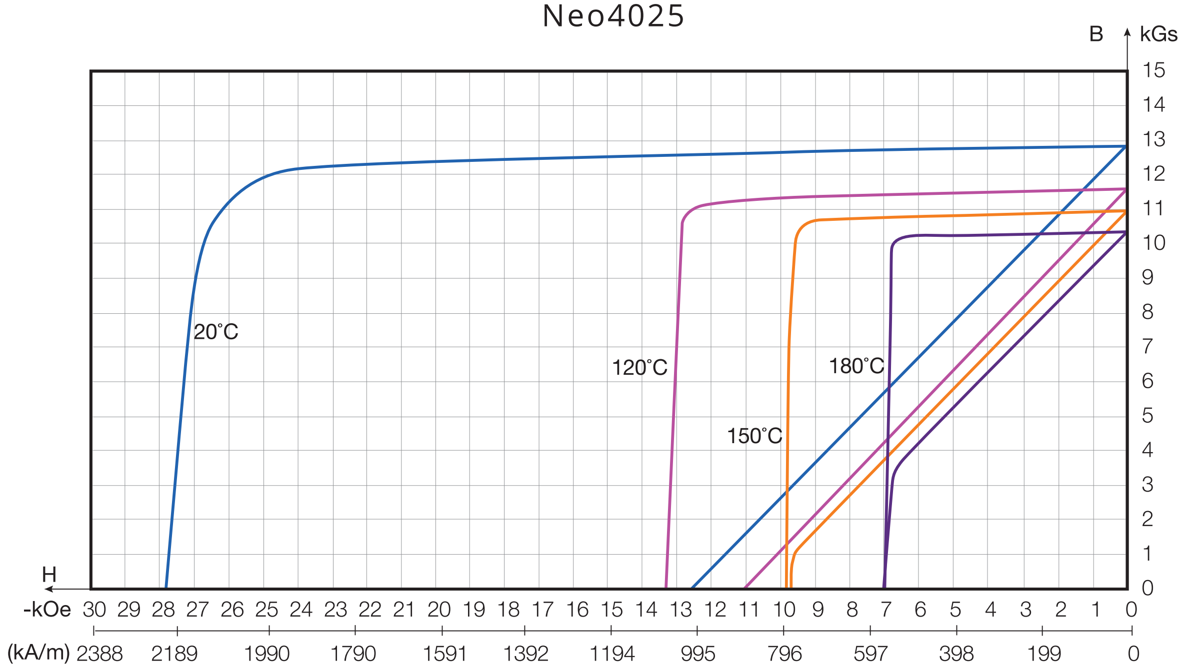
Neodymium demagnetization curves

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

Neo3525



Neo4025

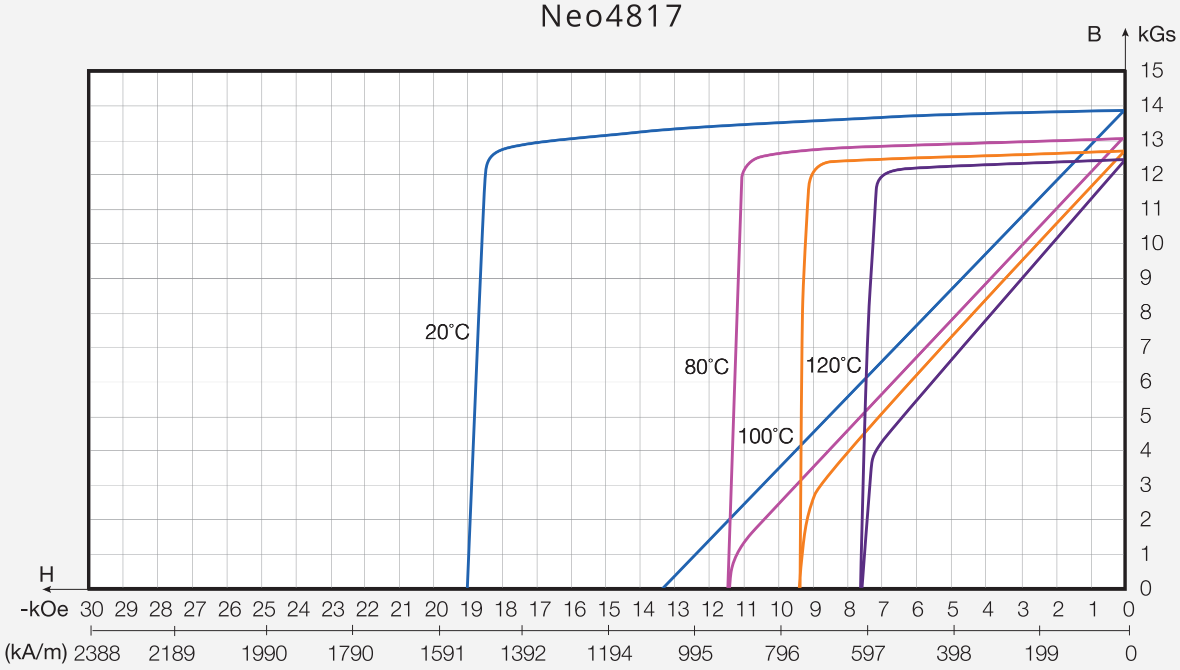


Curves for other material grades are available upon request.

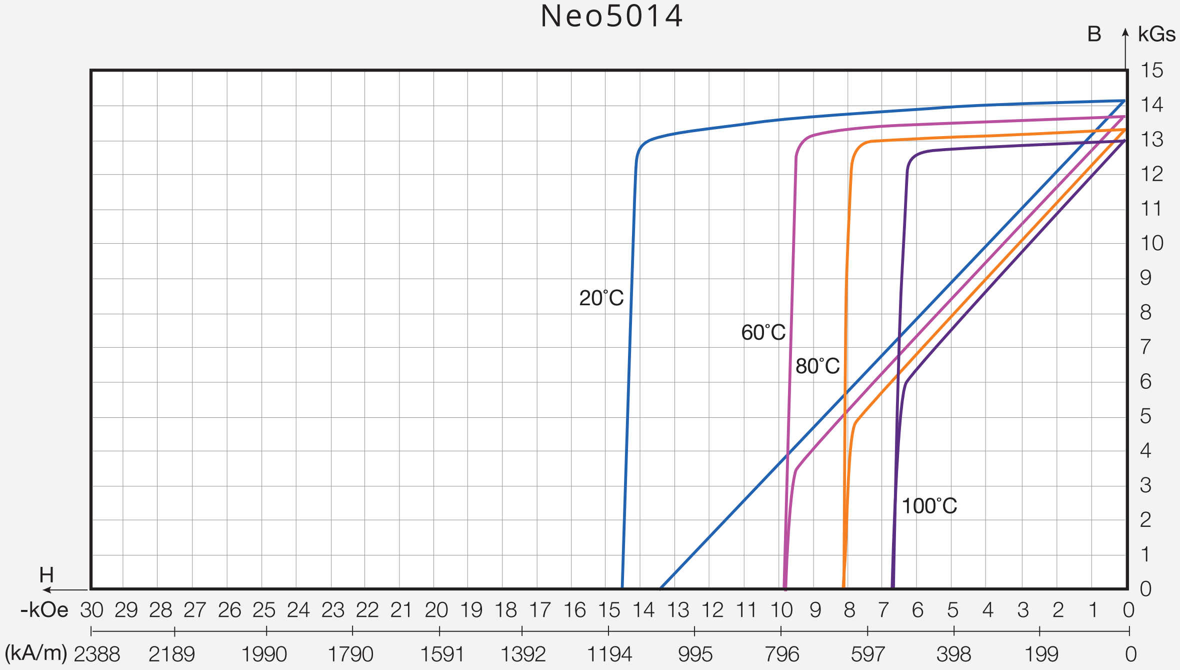
Neodymium demagnetization curves

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

Neo4817



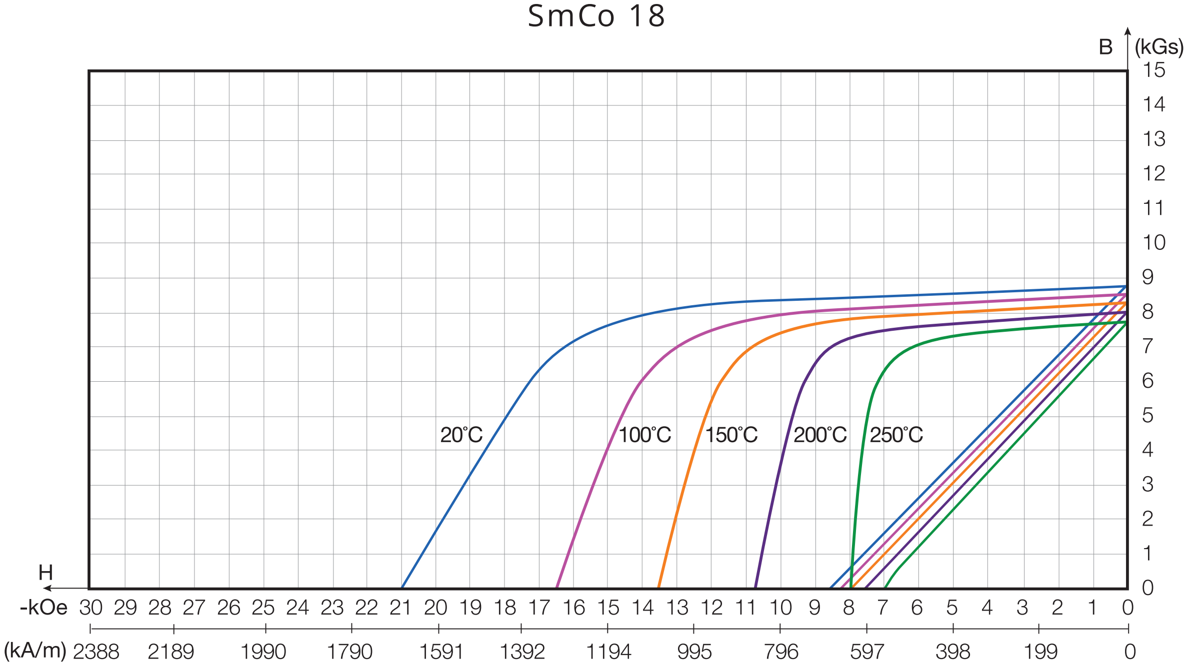
Neo5014

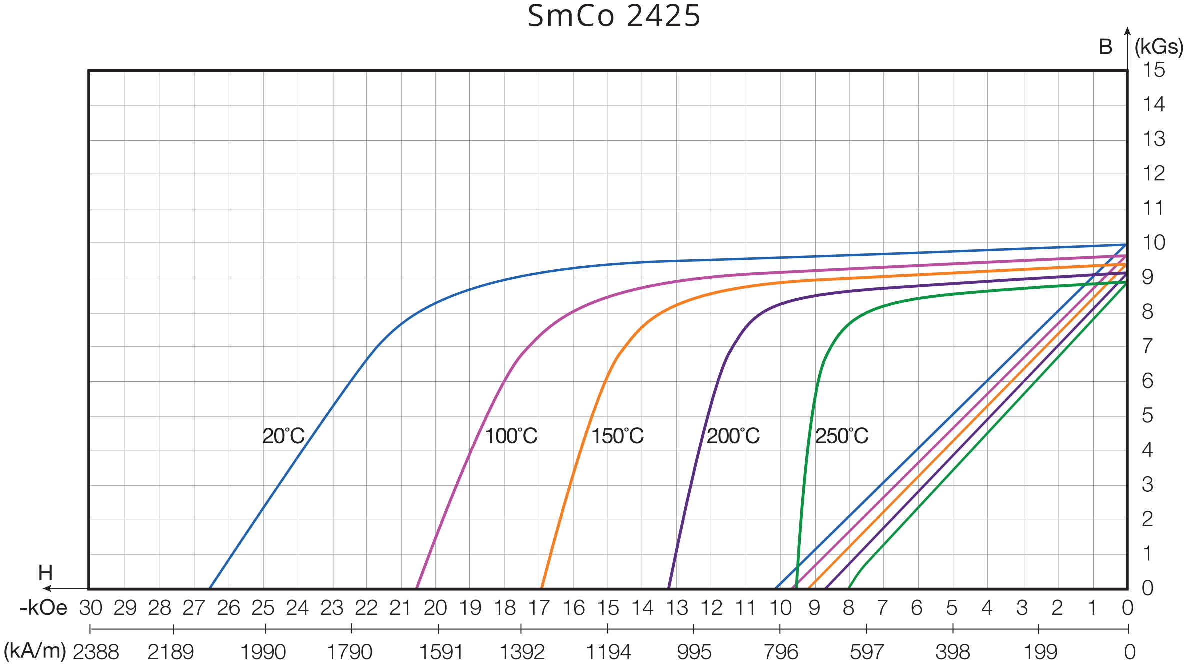


Curves for other material grades are available upon request.

Samarium Cobalt demagnetization curves

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



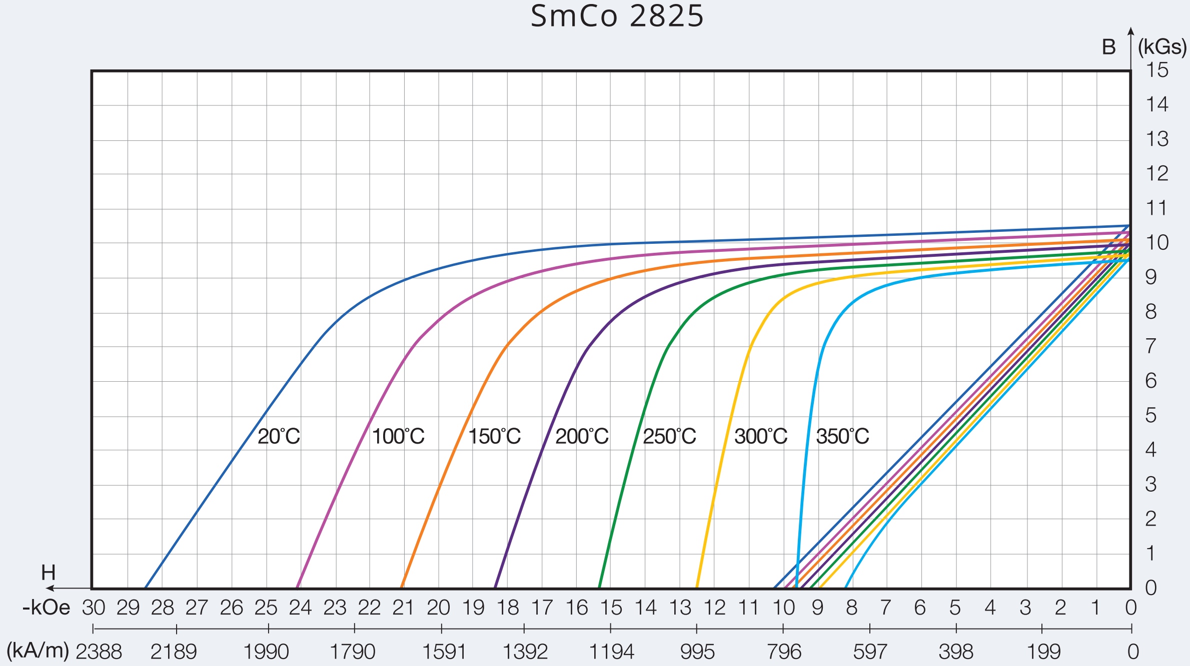


Curves for other material grades are available upon request.

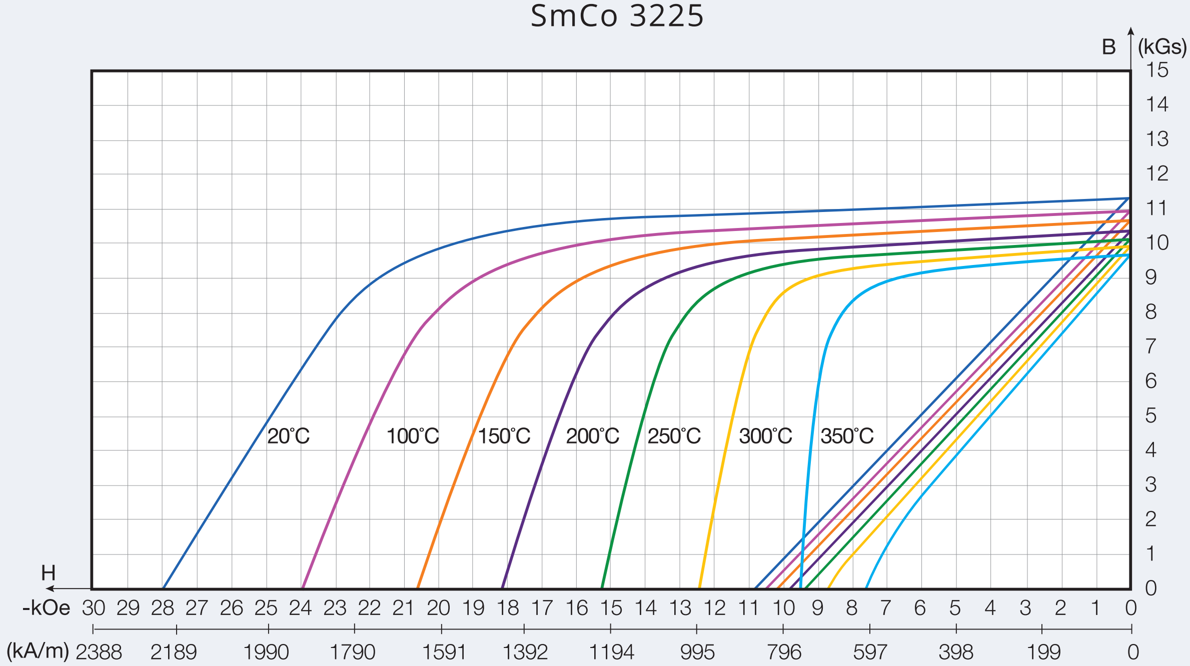
Samarium Cobalt demagnetization curves

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

SmCo 2825



SmCo 3225



Curves for other material grades are available upon request.

Alnico characteristics and curves

Most alnico magnets are manufactured using typical foundry casting techniques, where the molten alloy is poured into sand molds. Very small magnets, usually one ounce or less, are produced using the press and sinter techniques. Sintered Alnico magnets have features which make them particularly effective in very small precision devices. It is possible to sinter magnets with small holes and intricate shapes. Sintered magnets are available in both isotropic and anisotropic form and with a wide range of unit properties. Their magnetic properties are essentially like the cast magnets of equivalent grade.

Grinding and Tolerances

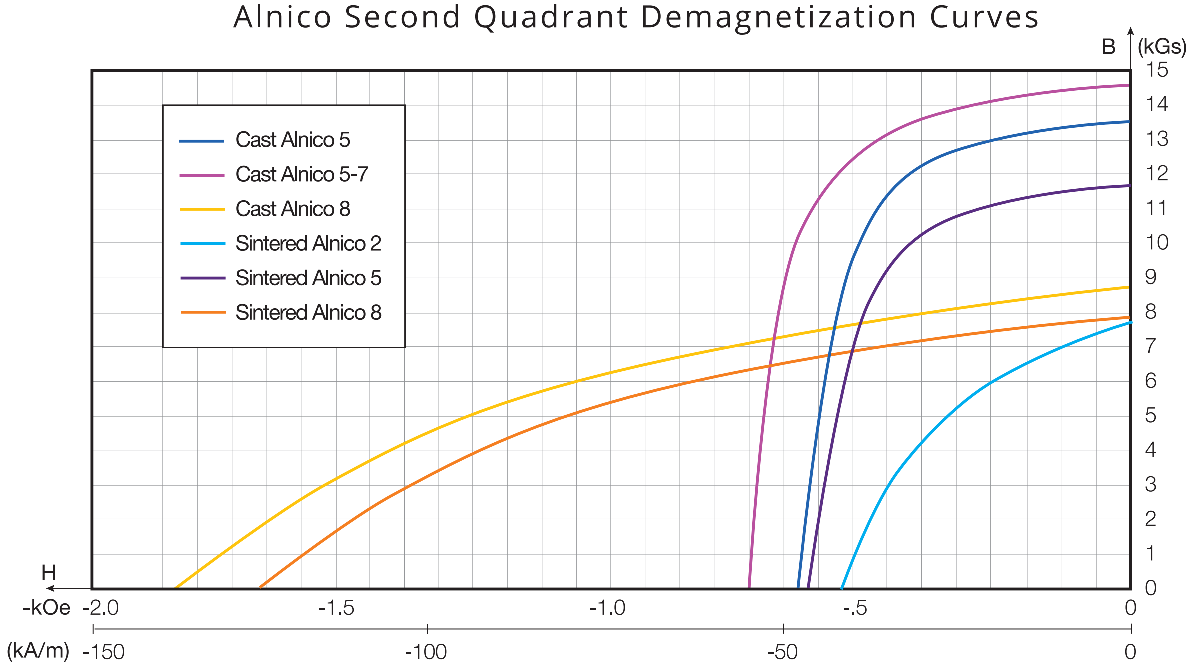
Alnico is hard and brittle (45-55 Rockwell C), and is not suitable for drilling, tapping or conventional machining operations. Close tolerances are attained by abrasive grinding and cutting. Adams provides in-house cutting and grinding to meet your application requirements.

Temperature Constraints and Magnetization

Alnico has the best temperature coefficient of any 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.

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. Alnico magnets 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. Care must be taken in handling magnetized magnets. 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. Check with Adams' technical staff to confirm best ratio for your application.

Alnico Second Quadrant Demagnetization Curves



Added value services

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 aluminum 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.

Gluing Magnets

The majority of magnets are assembled into magnet systems using adhesives. Such construction may require the adherence 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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