



Cast ALNICO Permanent Magnets



ALNICO PERMANENT MAGNETS

Introduction

For over 50 years an acknowledged leader in the field of permanent magnets, Arnold Engineering continues its tradition of superior quality and value with the full line of Alnico products presented in this catalog.

One of the oldest members of our magnet family, Alnico remains the workhorse of the permanent magnet industry and can be relied upon to deliver impressive flux density at an economical price. Alnico also boasts the lowest temperature coefficient of any commercial magnet material (.02% per degree centigrade) allowing for excellent stability over a wide temperature range.

Alnico has experienced renewed interest in recent years in such temperature-sensitive applications as hall-effect and MR-based automotive and electronic sensors, in addition to the traditional magnetron, TWT amplifiers, actuators, motors and instruments applications that have long relied upon Alnico.

Call Arnold Engineering today for applications engineering assistance, samples or pricing.

General characteristics

Alnico permanent magnets form a family of alloys whose major constituents are iron, aluminum, nickel and cobalt, though other elements (e.g., copper and titanium) may be included in minor amounts. Grades of Alnico vary in cobalt content, which ranges from zero (Alnico 3) to 40% (Alnico 8).

Lower grades (2, 3 and 4) are unoriented—magnetic properties are isotropic and equal in all directions. Their magnetic output is relatively low. Anisotropic grades (Alnico 5, 6, 8 and 9) are designed to produce high magnetic output in a specified direction. Orientation is achieved during heat treatment, by cooling the product from a temperature of about 2000°F (1093°C) at a controlled rate, within a magnetic field which conforms to the preferred direction of magnetization.

Alnico 5, the most widely used grade, can usually be depended upon to deliver energy to a magnetic circuit more economically than

any of the other Alnico grades. Alnico 8 possesses the highest coercive force of all Alnico grades, as well as excellent energy per unit volume and a low temperature coefficient. It is recommended for applications exposed to strong demagnetizing fields, or where space considerations dictate a short magnetic length.

ArKomax®800 and Alnico 9 are premium grades of Alnico 5 and 8, respectively. The superior magnetic output of these grades is produced by crystal orientation from the molten state in the desired direction of magnetization.

Manufacturing processes

Alnico magnets can be produced in a wide variety of shapes and sizes, ranging in weight from less than one ounce (28 grams) to over 80 pounds (36 kilograms).

The majority of magnets are cast in sand molds, following melting in a high-frequency induction furnace.

Magnets weighing less than an ounce (28 grams) may be produced by sintering. In this process, the desired mix of metal powders is pressed to shape and size in a die, and then sintered at a temperature of approximately 2300°F (1260°C) in a hydrogen atmosphere. The sintering process is well suited to large volume production and results in parts which are structurally stronger than cast magnets. Relatively close tolerances can be achieved without grinding.

Stock items and tooling

A variety of shapes and sizes in selected grades of Alnico have become standard over the years. A partial list of these parts is provided later in this manual. Arnold maintains the required tooling for these parts and in many cases has quantities of them in stock, ready for immediate shipment.

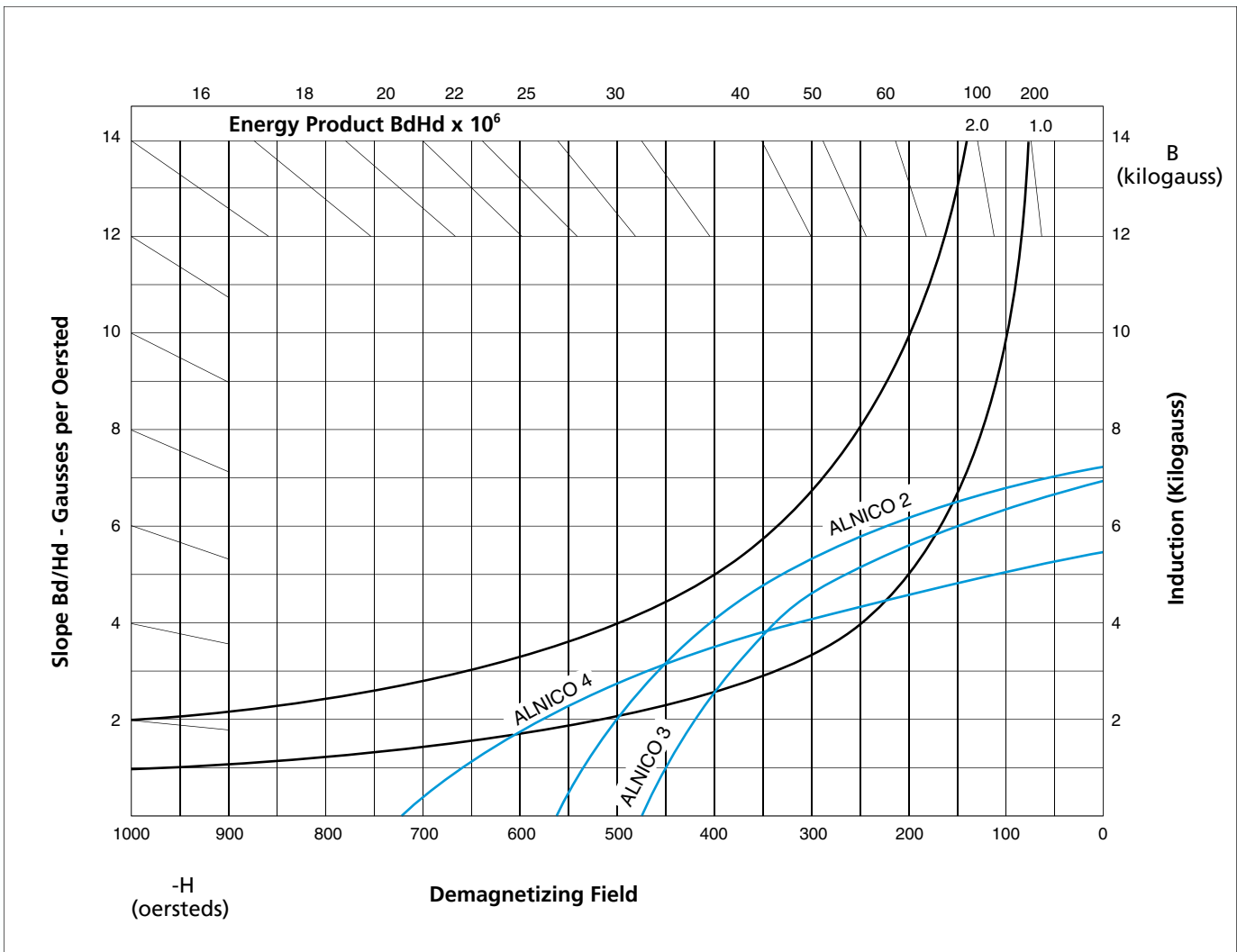
The use of stock items, especially on small quantity orders, can result in substantial savings to the user because the need for costly production tooling is eliminated.

Alnico 2,3,4

Magnetic and Physical Properties (Typical Values)

	Max. Energy Product $B_d \times H_d$		Residual Induction B_r	Required Magnetizing Field		Coersive Force H_c		Recoil Permeability		Permeance Coefficient B/H @ $(B_d H_d)$ Max.		Induction at Maximum Energy Product	
	MGOe	KJ/m ³	mT	Oe	KA/m	Oe	KA/m	G/Oe	10 ⁻³ Tm/KA	G/Oe	10 ⁻³ Tm/KA	G	mT
Alnico 2	1.60	12.7	720	2000	160	560	45	6.2	7.8	12.0	15.0	4400	440
Alnico 3	1.40	11.1	700	2000	160	475	38	5.1	6.4	14.0	17.5	4450	445
Alnico 4	1.35	10.7	550	3000	240	720	57	4.1	5.2	7.0	9.0	3100	310

Typical Demagnetization Curves



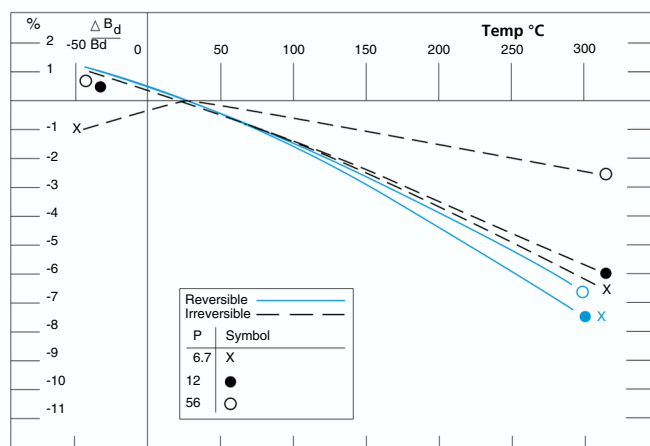
Alnico 2, 3, 4

Magnetic and Physical Properties (Typical Values)

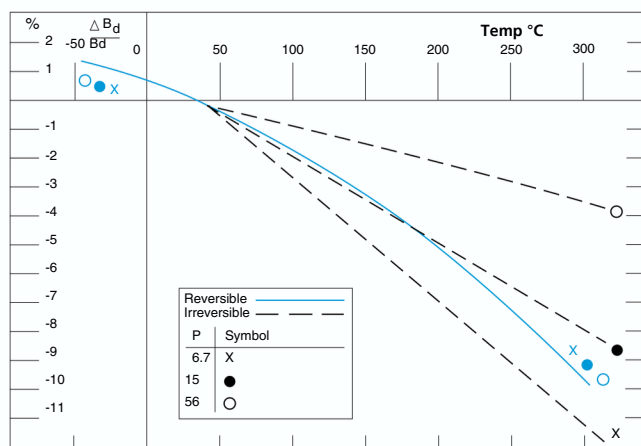
	Density		Electrical Resistivity	Tensile Strength		Transverse Modulus of Rupture		Coefficient of Thermal Expansion	Hardness Rockwell C
	lb./in. ³	gr/cm ³	25°C (μΩcm)	PSI	N/mm ²	PSI	N/mm ²	per °C x 10 ⁶	
Alnico 2	0.257	7.11	65	3000	20	7200	50	12.4	45
Alnico 3	0.249	6.89	60	12000	80	23000	160	13.0	45
Alnico 4	0.253	7.00	65	9000	60	24000	165	13.1	45

Temperature Effects

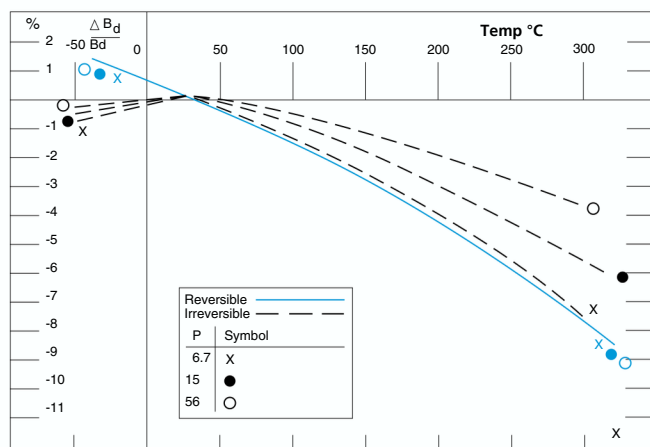
Alnico 2



Alnico 3



Alnico 4

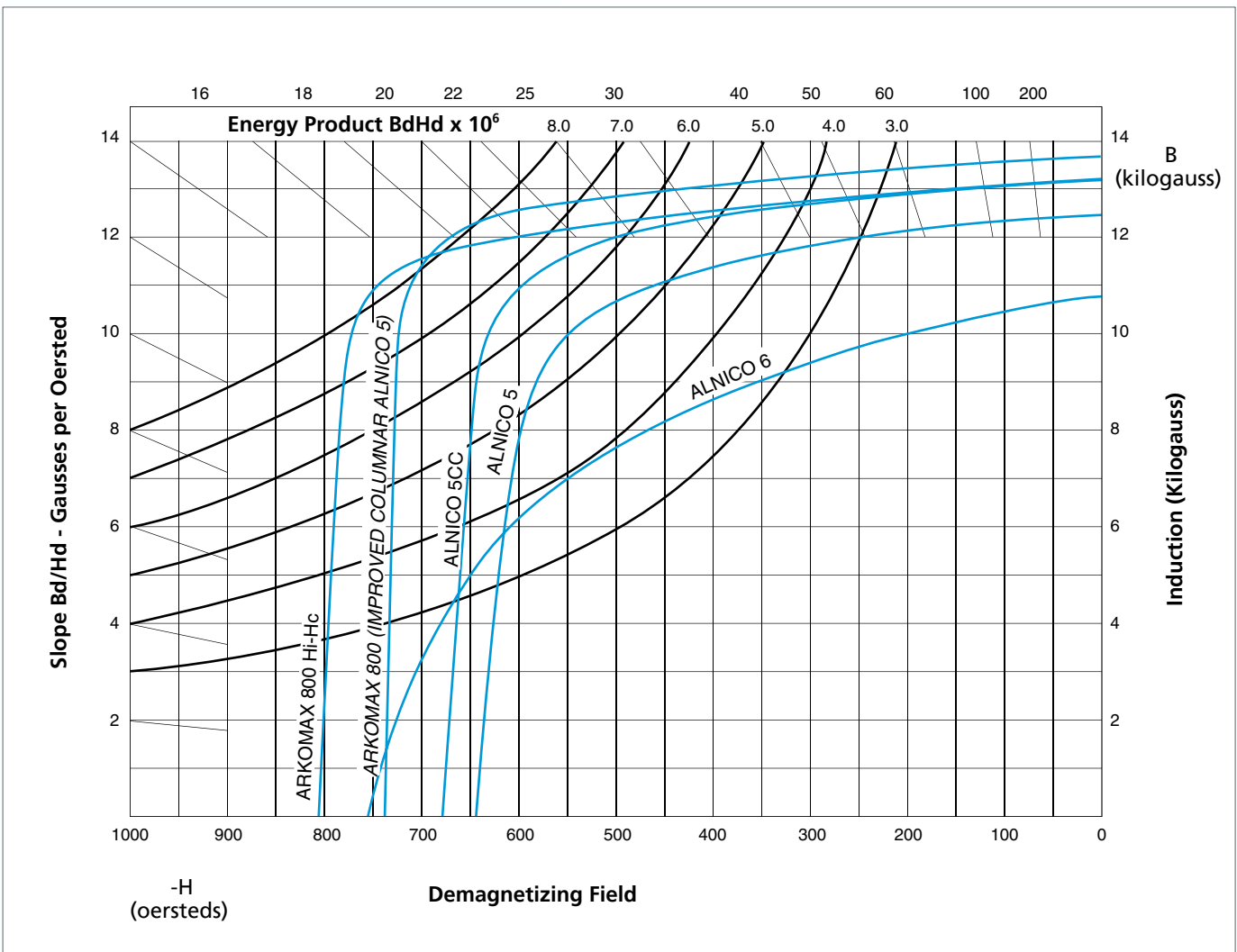


Alnico 5, 5cc, 6 & ArKomax® 800, 800 Hi-Hc

Magnetic and Physical Properties (Typical Values)

	Max. Energy Product $B_d \times H_d$		Residual Induction B_r		Required Magnetizing Field		Coersive Force H_c		Recoil Permeability		Permeance Coefficient B/H @ $(B_d H_d)$ Max.		Induction at Maximum Energy Product	
	MGOe	KJ/m ³	G	mT	Oe	KA/m	Oe	KA/m	G/Oe	10 ⁻³ Tm/KA	G/Oe	10 ⁻³ Tm/KA	G	mT
Alnico 5	5.50	43.8	12500	1250	3000	240	640	51	3.7	4.6	19.0	24.0	10000	1000
Alnico 5cc	6.50	51.7	13200	1320	3000	240	675	54	2.4	3.0	18.5	23.0	11000	1100
Alnico 6	3.90	31.0	10800	1080	3000	240	750	60	5.6	7.0	14.0	17.5	7400	740
ArKomax® 800	8.10	64.5	13700	1370	3000	240	740	59	2.0	2.5	18.0	22.5	12000	1200
ArKomax® 800 Hi-Hc	8.10	64.5	13200	1320	3000	240	810	64	2.0	2.5	15.5	19.5	11200	1120

Typical Demagnetization Curves



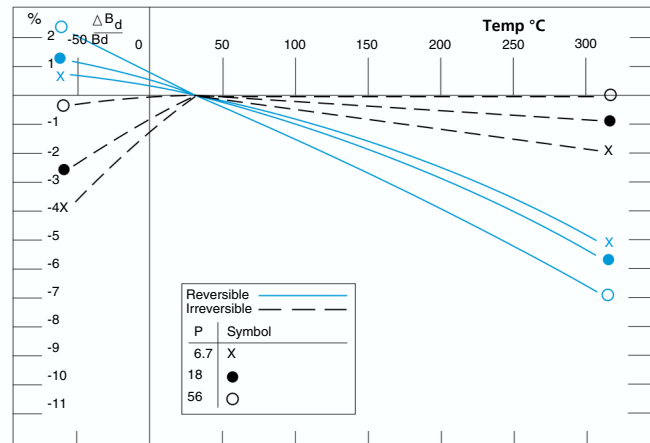
Alnico 5, 5cc, 6 & ArKomax® 800, 800 Hi-Hc

Magnetic and Physical Properties (Typical Values)

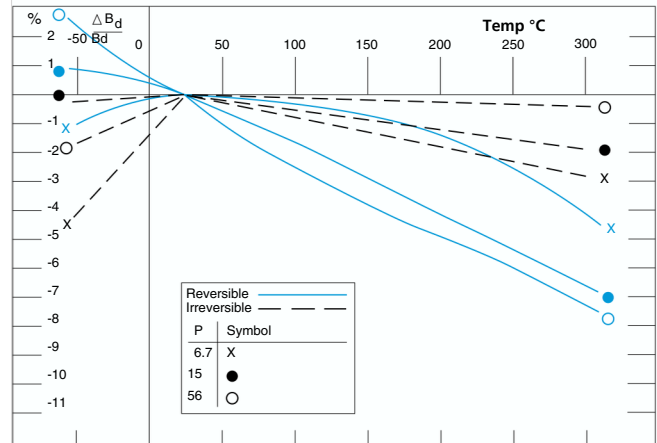
	Density		Electrical Resistivity	Tensile Strength		Transverse Modulus of Rupture		Coefficient of Thermal Expansion	Hardness Rockwell C
	lb./in. ³	gr/cm ³	25°C (μΩcm)	PSI	N/mm ²	PSI	N/mm ²	per °C x 10 ⁶	
Alnico 5	0.264	7.31	47	5500	40	10000	70	11.5	50
Alnico 5cc	0.264	7.31	47	5200	35	9000	60	11.5	50
Alnico 6	0.265	7.34	50	23000	160	45000	310	11.4	50
ArKomax® 800	0.264	7.31	47	5000	35	8000	55	11.5	50
ArKomax® 800 Hi-Hc	0.264	7.31	47	5000	35	8000	55	11.5	50

Temperature Effects

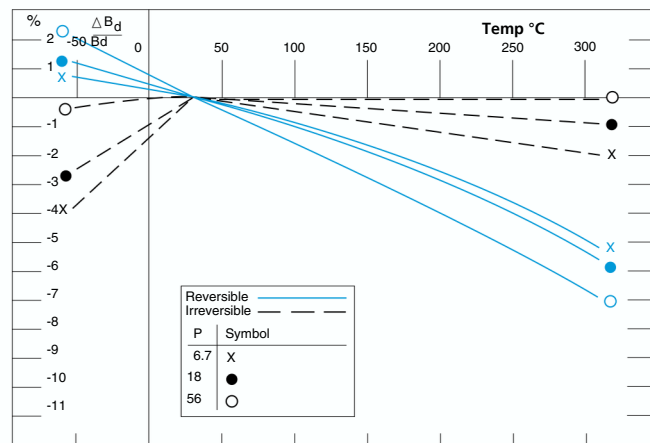
Alnico 5 Alnico 5cc



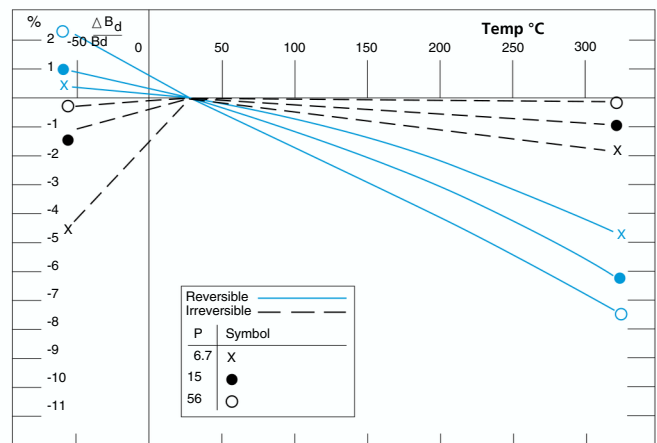
Alnico 6



ArKomax® 800



ArKomax® 800 Hi-Hc

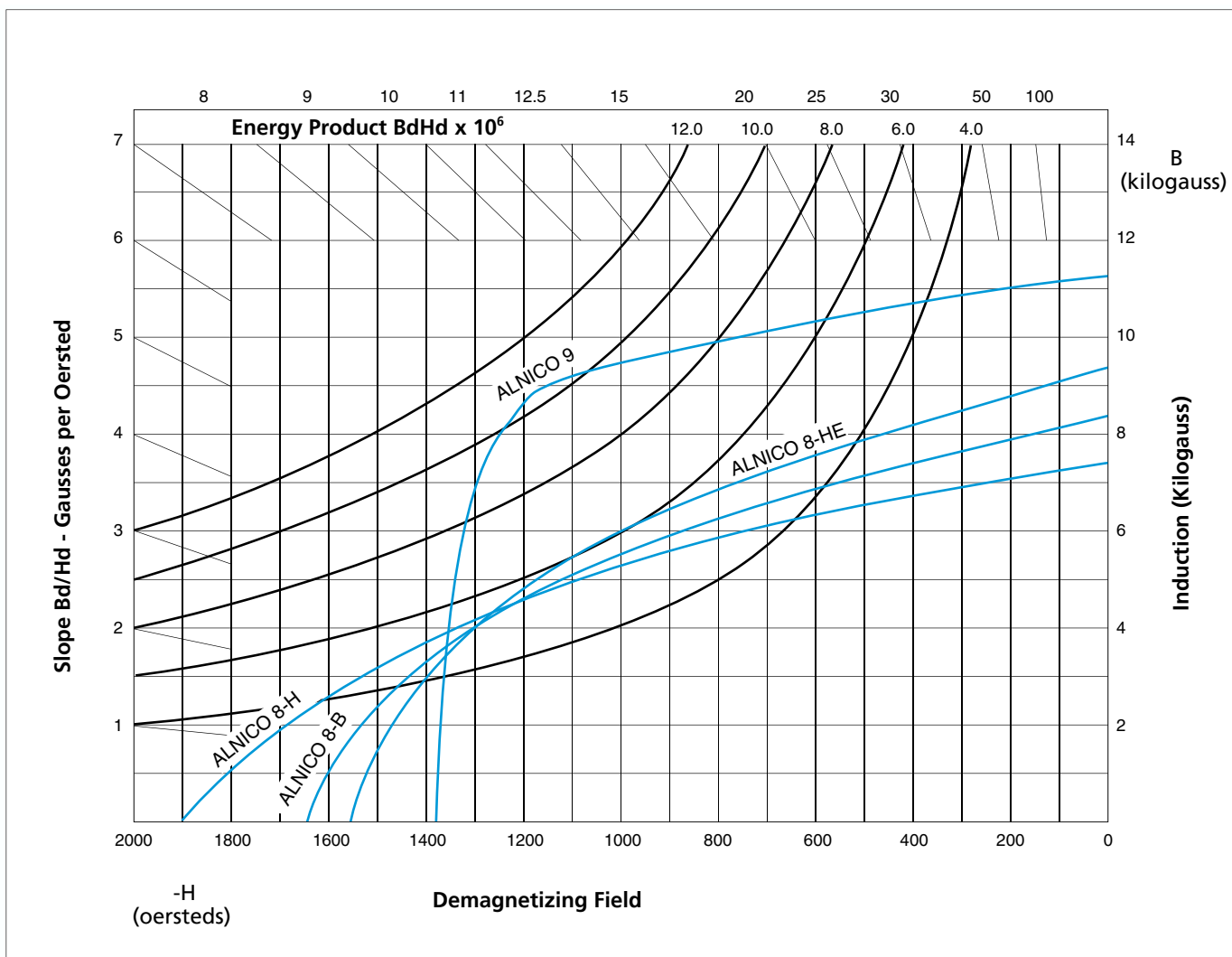


Alnico 8B, 8HE, 8H, 9

Magnetic and Physical Properties (Typical Values)

	Max. Energy Product $B_d \times H_d$		Residual Induction B_r		Required Magnetizing Field		Coersive Force H_c		Recoil Permeability		Permeance Coefficient B/H @ $(B_d H_d)$ Max.		Induction at Maximum Energy Product	
	MGOe	KJ/m ³	mT	G	Oe	KA/m	Oe	KA/m	G/Oe	10 ⁻³ Tm/KA	G/Oe	10 ⁻³ Tm/KA	G	mT
Alnico 8B	5.50	43.8	8300	830	6000	480	1650	131	2.0	2.5	4.5	5.5	5000	500
Alnico 8HE	6.00	47.7	9300	930	6000	480	1550	123	2.0	2.5	5.5	7.0	5750	575
Alnico 8H	5.50	43.8	7400	740	6000	480	1900	151	2.0	2.5	3.5	4.5	4400	440
Alnico 9	10.50	83.6	11200	1120	6000	480	1375	109	1.3	1.6	7.5	9.5	8900	890

Typical Demagnetization Curves



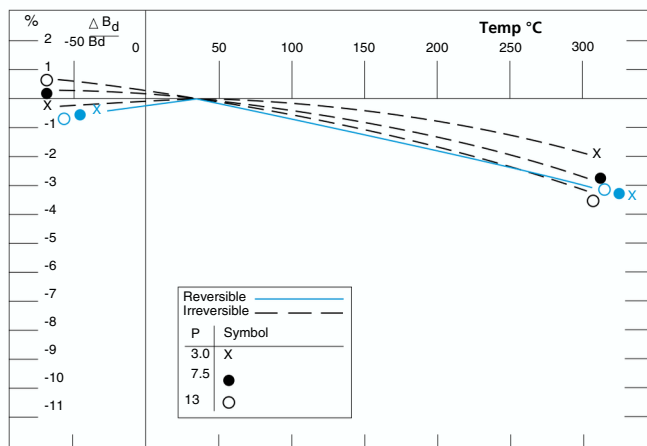
Alnico 8B, 8HE, 8H, 9

Magnetic and Physical Properties (Typical Values)

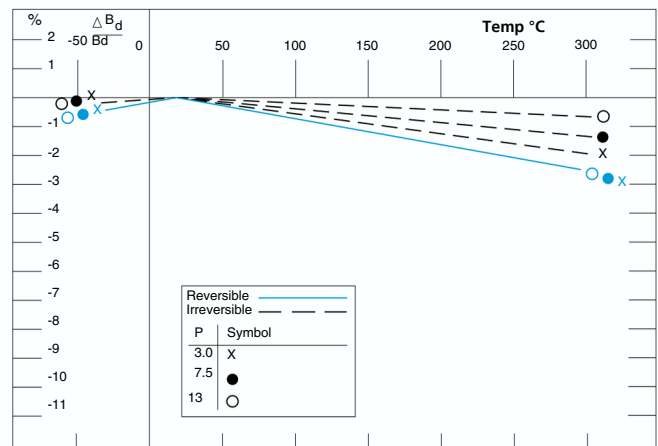
	Density		Electrical Resistivity	Tensile Strength		Transverse Modulus of Rupture		Coefficient of Thermal Expansion	Hardness Rockwell C
	lb./in. ³	gr/cm ³	25°C (μΩcm)	PSI	N/mm ²	PSI	N/mm ²	per °C x 10 ⁶	
Alnico 8B	0.262	7.25	50	9000	60	30000	205	11.0	56
Alnico 8HE	0.262	7.25	50	10000	70	30000	205	11.0	56
Alnico 8H	0.262	7.25	50	8500	60	30000	205	11.0	56
Alnico 9	0.262	7.25	50	7000	50	8000	55	11.0	56

Temperature Effects

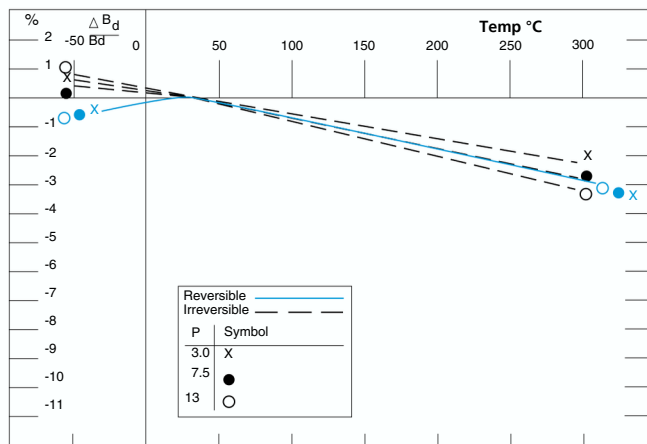
Alnico 8B



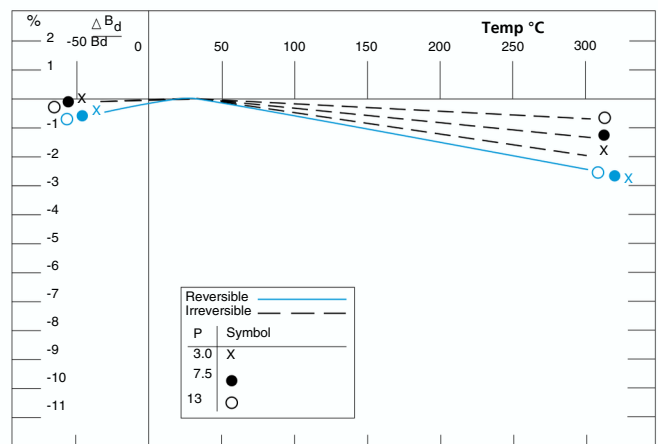
Alnico 8HE



Alnico 8H



Alnico 9



Standard Alnico Tolerances

Cast Alnico

Dimension		Tolerance	
Up to 1"	Up to 25.4 mm	±1/64	.40 mm
1" to 3"	25.4 to 76.2 mm	"	.81 mm
3" to 5"	76.2 to 127.0 mm	±1/32	1.19 mm
5" to 7"	127.0 to 177.8 mm	"	1.59 mm
7" to 9"	177.8 to 228.6 mm	±3/64	1.98 mm

Sintered Alnico

Dimension		Tolerance	
Up to .125"	Up to 3.18 mm	±.004	.13 mm
.126" to .625"	3.20 to 15.88 mm	"	.25 mm
.626" to 1.250"	15.90 to 31.75 mm	±.010	.25 mm
		"	.38 mm

Concentricity

Concentricity between inside and outside as cast diameters: .031" (.79 mm) F.I.R. when hole diameter is greater than hole length. 1.5 X total O.D. tolerance F.I.R. when hole diameter is less than hole length.

Squareness

Perpendicularity between one ground surface and an "as cast" surface is ±1-1/2 degrees.

Finish

Permanent magnet materials can be finish ground when dimensional tolerances closer than the initial manufacturing tolerances are required.

Magnets with surfaces marked "f" will be furnished with these surfaces finish ground. All other surfaces will be "as cast" or "as sintered."

Ground Surfaces

Normal tolerance between ground surface is ±.005" (.13 mm).

Perpendicularity between two ground surfaces is ±1/2 degree.

Magnetization

Unless otherwise specified, stock magnets will be furnished in a magnetized condition. The direction of magnetization is designated by

← M →. On some parts, polarity is shown as N-S.

Caution: Care should be taken in handling magnetized magnets. Magnets should not be placed in repelling positions or exposed to stray ac fields as these conditions will affect their performance.

Design Considerations

Because Alnico magnets are coarse-grained, hard and brittle, they cannot be drilled or conventionally machined.

Given these mechanical properties, Alnico parts are not used as structural members. Where a choice exists, select simple shapes. Slots are preferred over holes. Cross sections of less than .125" (3.18 mm) should be avoided. Finished surfaces, when required, may be produced by grinding; however, for many applications, the "as cast" or "as sintered" surface yields a satisfactory result at a significantly lower cost.

To facilitate mounting and give adequate protection to the magnet, special assemblies such as rotors and magnetron magnets may be supplied with an aluminum jacket. Additionally, low carbon steel pole pieces may be attached to magnet pole faces by adhesive bonding or with studs or bolts. Plastisol or paint can be applied for improved appearance.

Magnetization

The most efficient use of Alnico requires that it be magnetized after the magnet has been assembled with its pole pieces into the final magnetic circuit. (Shipping the product non-magnetized also eliminates the need for special packaging, and prevents contamination by stray iron-chips, etc.)

Magnetic saturation at the end-use location requires the application of a magnetizing force 4 to 5 times greater than the coercive force of the material. For Alnico 5, 3000 oersteds (240 KA/M) are recommended. For Alnico 8, the force should be at least 7000 oersteds (560 KA/M).

The magnetizing force need be applied only momentarily. Thus, impulse magnetizers employing a capacitor discharge are commonly used. Direct current apparatus are also effective.

Stability and temperature effects

Alnico magnets offer excellent stability with respect to temperature changes: reversible change is 0.02% per degree Centigrade. Heating may produce an irreversible loss of magnet strength. The magnitude of loss depends upon the dimensions of the magnet and its composition, but is usually less than 5%, and may be recovered by remagnetization.

At temperatures exceeding 1000°F (538°C), a metallurgical change takes place which causes magnetic strength to reduce rapidly. This change will not be recovered by remagnetization.

External magnetic fields can also induce partial demagnetization. In some critical applications, it is desirable to stabilize the magnet by intentionally reducing magnetic output by 5% to 10%. Such stabilization may reduce, or even eliminate, the effect of stray external fields.

Alnico Ordering Information

Please refer to Alnico Product Specification Sheets when ordering standard Alnico permanent magnets. The magnets listed on these specification sheets, however, represent only a small percentage of the wide variety of shapes and sizes available in the various grades of Alnico. We invite your inquiries concerning magnet designs other than those listed. These inquiries should be submitted to Arnold Engineering, Marengo, Illinois, or to the nearest Arnold sales office.

It is our desire to respond to your inquiries rapidly and accurately. In order to do this, your requests should contain certain magnetic, mechanical, and general information to better serve you. Please use the Request for Quotation Form on the back of this sheet to speed the processing of your inquiry. Photocopy this form, fill it in with the necessary information, and then fax or mail to The Arnold Engineering Company.

All inquiries should include:

Inquiry reference number; part number; quantity of parts required; annual part usage; the address and person to whom the quotation should be submitted.

If a design has already been determined, your inquiry should include:

A sketch or print of the part or assembly; all dimensions and tolerances; material grade required; direction of orientation; whether the part is to be magnetized.

If you require design assistance, our staff of engineers will be happy to assist you. In addition to all of the information mentioned previously, the following would be helpful in making recommendations:

Operating point of the magnet; required flux density; physical stress placed on the magnet; demagnetizing forces; temperature range; a description of the magnetic circuit; proposed method of mounting; any application information available.

In many instances, Arnold will already have adequate tooling available to make parts to your specifications. This could result in substantial savings. It is always our goal to provide the customer with the most efficient and economical part for a given application. Detailed inquiry information will help us to achieve this.

Limited Warranty and Exclusive Remedy

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Request for Quotation

For 24-hour turn-around on quotations:

MAIL TO:

Customer Service
THEARNOLDENGINEERING COMPANY
Alnico Products Division
300North WestStreet
Marengo, IL 60152

FAX TO:

(815) 568-2376

Company:

Inquiry No.:

Address:

Reply Requested By:

Fax

Mail

Phone

E-

Phone No.:

Fax No.:

Arnold Part No.: mail

E-mail:

Material:

Reply To:

Magnetized:

Application and General Information:

Direction of Orientation:

Delivery Requested:

Quantity/Estimated Annual Usage:

Print or sketch —Please include description: all dimensions and tolerances; material; magnetic requirements and material grade required; type of coating and color.



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