



Standard Specification for Cast and Sintered Alnico Permanent Magnets¹

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1. Scope

1.1 This specification covers technically important, commercially available, magnetically hard, cast and sintered permanent magnets known commonly as Alnico.

1.2 Alnico magnets have approximate magnetic properties of residual magnetic induction, B_r , from 0.52 T (5200 G) to 1.35 T (13500 G) and coercivity, H_{cB} , from 38 kA/m (475 Oe) to 175 kA/m (2200 Oe). Their specific magnetic hysteresis behavior (demagnetization curves) can be characterized using Test Method A977/A977M.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to customary (cgs-emu and inch-pound) units which are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A977/A977M Test Method for Magnetic Properties of High-Coercivity Permanent Magnet Materials Using Hysteresisographs

2.2 Other Standards:

MMPA Standard No. 0100-00 Standard Specifications for Permanent Magnet Materials³

¹ This specification is under the jurisdiction of ASTM Committee A06 on Magnetic Properties and is the direct responsibility of Subcommittee A06.02 on Material Specifications.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ MMPA Standard No. 0100-00 is now available from the Permanent Magnet Division of the SMAA (www.smaa.org). It was previously available from The International Magnetics Association (IMA). The IMA had been the successor to the MMPA and both organizations no longer exist.

IEC 60404-8-1 Magnetic Materials Part 8: Specifications for Individual Materials Section 1 – Standard Specifications for Magnetically Hard Materials⁴

3. Terminology

3.1 The terms and symbols used in this specification are defined in Terminology A340, except as noted in 3.2.

3.2 Terms that are not defined in Terminology A340 but are in common usage and used herein are as follows.

3.2.1 Recoil permeability, $\mu_{(rec)}$, is the permeability corresponding to the slope of the recoil line. For reference see incremental, relative, and reversible permeabilities as defined in Terminology A340. In practical use, this is the slope of the normal hysteresis loop in the second quadrant and in proximity to the B-axis. The value of recoil permeability is dimensionless. Note that in producers' product literature recoil permeability is sometimes represented by the symbol μ_r , which is defined by Terminology A340 as relative permeability.

3.2.2 Magnetic characteristics change with temperature. Two key metrics of permanent magnet performance are residual induction, B_r , and intrinsic coercive field strength, H_{cJ} . The change in characteristic over a defined and limited temperature range can be reversible, that is, non-destructive. This change is represented by values called reversible temperature coefficients. The symbol for reversible temperature coefficient of induction is $\alpha(B_r)$ and for (intrinsic) coercivity is $\alpha(H_{cJ})$. They are expressed in percent change per degree Celsius, %/°C, or the numerically equivalent percent per Kelvin, %/K. The changes in magnetic characteristics are non-linear so it is necessary to specify the temperature range over which the coefficient applies.

3.2.3 The maximum recommended working temperature, T_w , of a permanent magnet is a semi-arbitrary value sometimes assigned by magnet manufacturers to their products. T_w is not normative. See Appendix X3 for a more complete discussion.

4. Classification

4.1 The classification of Alnico permanent magnets is given in Table 1, and Appendix X1, Table X1.1, with cross-reference to MMPA Standard No. 0100-00 and IEC 60404-8-1.

⁴ Available from International Electrotechnical Commission (IEC), 3, rue de Varembe, 1st Floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, http://www.iec.ch.

TABLE 1 Alnico Magnets: Minimum Magnetic Property Requirements^A

NOTE 1—“...” indicates that there is no known published data.

ASTM Designation ^B	Chemical Composition ^C					Maximum Energy Product (BH) _{max}		Residual Induction B _r		Coercive Field Strength H _{cB}		Intrinsic Coercive Field Strength H _{cJ}	
	Al	Ni	Co	Cu	Ti	kJ/m ³	(MGOe)	mT	(G)	kA/m	(Oe)	kA/m	(Oe)
CAST ISOTROPIC ALNICO													
AL-CI-9/47	...	...	...	...	...	9.0	(1.1)	550	(5500)	44.0	(553)	47.0	(591)
AL-CI-10/38	12	25	...	3	...	9.7	(1.2)	665	(6650)	36.3	(456)	37.8	(475)
AL-CI-12/55	...	...	...	...	...	11.6	(1.5)	630	(6300)	52.0	(653)	55.0	(691)
AL-CI-12/44	10	19	13	3	...	12.2	(1.5)	713	(7125)	42.3	(532)	43.8	(551)
AL-CI-17/86	...	...	...	...	...	17.0	(2.1)	580	(5800)	80.0	(1005)	86.0	(1081)
CAST ANISOTROPIC ALNICO													
AL-CA-28/61	8	16	24	3	1	27.9	(3.5)	998	(9975)	59.0	(741)	60.5	(760)
AL-CA-36/148	...	...	...	...	...	36.0	(4.5)	700	(7000)	140.0	(1759)	148.0	(1860)
AL-CA-37/49	...	...	...	...	...	37.0	(4.6)	1180	(11 800)	48.0	(603)	49.0	(616)
AL-CA-38/112	...	...	...	...	...	38.0	(4.8)	800	(8000)	110.0	(1382)	112.0	(1407)
AL-CA-36/164	8	14	38	3	8	35.8	(4.5)	684	(6840)	143.6	(1805)	164.1	(2062)
AL-CA-38/141	7	15	35	4	5	38.0	(4.8)	779	(7790)	124.7	(1568)	140.6	(1767)
AL-CA-39/49	8	14	24	3	...	39.4	(5.0)	1216	(12 160)	48.4	(608)	48.8	(613)
AL-CA-44/53	...	...	...	...	...	44.0	(5.5)	1200	(12 000)	52.0	(653)	53.0	(666)
AL-CA-47/51	8	14	24	3	...	46.6	(5.9)	1264	(12 635)	50.7	(637)	51.0	(641)
AL-CA-58/53	...	...	...	...	...	58.0	(7.3)	1300	(13 000)	52.0	(653)	53.0	(666)
AL-CA-54/56	8	14	24	3	...	53.7	(6.8)	1283	(12 825)	55.9	(703)	56.3	(708)
AL-CA-60/112	...	...	...	...	...	60.0	(7.5)	900	(9000)	110.0	(1382)	112.0	(1407)
AL-CA-65/115	7	15	35	4	5	64.5	(8.1)	1007	(10 070)	113.4	(1425)	114.5	(1439)
AL-CA-72/120	...	...	...	...	...	72.0	(9.0)	1050	(10 500)	118.0	(1483)	120.0	(1508)
SINTERED ISOTROPIC ALNICO													
AL-SI-9/47	...	...	...	...	...	9.0	(1.1)	550	(5500)	44.0	(553)	47.0	(591)
AL-SI-12/55	...	...	...	...	...	11.6	(1.5)	630	(6300)	52.0	(653)	55.0	(691)
AL-SI-11/43	10	19	13	3	...	10.7	(1.4)	675	(6745)	41.6	(523)	43.1	(542)
AL-SI-17/86	...	...	...	...	...	17.0	(2.1)	580	(5800)	80.0	(1005)	86.0	(1081)
SINTERED ANISOTROPIC ALNICO													
AL-SA-21/62	8	15	24	3	1	20.8	(2.6)	893	(8930)	59.7	(751)	62.0	(779)
AL-SA-26/58	...	...	...	...	...	26.0	(3.3)	900	(9000)	56.0	(704)	58.0	(729)
AL-SA-28/48	8	14	24	3	...	27.9	(3.5)	1036	(10 355)	46.9	(589)	47.6	(599)
AL-SA-31/111	...	...	...	...	...	31.0	(3.9)	760	(7600)	107.0	(1345)	111.0	(1395)
AL-SA-29/128	7	15	35	4	5	28.6	(3.6)	703	(7030)	113.4	(1425)	127.8	(1606)
AL-SA-33/150	...	...	...	...	...	33.0	(4.1)	650	(6500)	135.0	(1696)	150.0	(1885)
AL-SA-34/48	...	...	...	...	...	34.0	(4.3)	1120	(11 200)	47.0	(591)	48.0	(603)
AL-SA-32/153	7	14	38	3	8	32.2	(4.1)	637	(6365)	136.1	(1710)	152.7	(1919)

^AMagnetic properties are minimum for +20 ± 2 °C (+68 ± 4 °F) and for a fully magnetized specimen.

^BASTM Designations are of the form *MM-TT-XX/YY* where:

MM = material (AL = Alnico),

TT = type of processing and orientation (CI = cast isotropic (non-oriented), CA = cast anisotropic (oriented), SI = sintered isotropic (non-oriented), SA = sintered anisotropic (oriented)),

XX = energy product in kJ/m³ rounded to the nearest integer, and

YY = intrinsic coercivity in kA/m rounded to the nearest integer.

^CComposition are representative and approximate and are non-mandatory information. The numbers presented here are weight percent.

5. Ordering Information

5.1 Orders for parts conforming to this specification shall include the following information:

5.1.1 Reference to this specification and year of issue/revision.

5.1.2 Reference to an applicable part drawing.

5.1.3 Magnetic property requirements if they are more stringent than the minimum values listed in the tables.

5.1.4 Quantity required.

 5.1.5 The required magnetization state of the provided material (unmagnetized, fully magnetized, magnetized and thermally stabilized, magnetized and then partially demagnetized—see [Appendix X3](#) for an explanation of terms). This information should appear on the part drawing whenever possible.

5.1.6 Certification of magnetic property evaluation.

5.1.7 Marking and packaging requirements.

5.1.8 Exceptions to this specification or special requirements such as plating, coating, or functional testing as mutually agreed upon by the producer and user.

6. Chemical Composition

 6.1 The general chemical composition of Alnico magnets is aluminum, nickel, and cobalt with selected transition metals and minor constituents and the balance of the composition being iron. Approximate chemical compositions for each grade are listed in [Table 1](#) and are typical but not mandatory.

7. Physical and Mechanical Properties

 7.1 Typical thermal and physical properties are listed in [Appendix X2, Table X2.1](#).

7.2 Physical density values are given for information purposes only and are not mandatory.

7.3 Alnico magnets are used for their magnetic characteristics. The end-use application should not rely on them for structural purposes due to low tensile and flexural strength. These materials are brittle and can chip or break easily. Magnetic properties may also be affected by physical stress.

8. Magnetic Property Requirements

8.1 Magnetic properties are listed in [Table 1](#).

8.2 The values of essential magnetic properties listed in the table are specified minimum values at $+20 \pm 2$ °C ($+68 \pm 4$ °F), determined after magnetizing to saturation in closed magnetic circuit.

8.3 The specified values of magnetic properties are valid only for magnet test specimens with a uniform cross-section along the axis of magnetization. Properties for anisotropic (magnetically oriented) magnets are measured along the axis of preferred orientation.

8.4 Because of the nature of permanent magnet production, magnetic testing of each lot is strongly recommended, especially for applications where the magnet performance is closely specified. Such magnetic property evaluations shall be conducted in the manner described below. Where the magnet shape is not suitable for magnetic testing, a specimen shall be cut from the magnet using appropriate slicing and grinding techniques, paying attention to any magnetic orientation within the magnet.

8.4.1 The magnetic properties shall be determined in accordance with Test Method [A977/A977M](#), or by using a suitable, mutually agreed upon magnetometric method.

8.4.2 When magnets are being purchased in the fully magnetized condition, the testing shall determine the magnetic properties from the as-received magnetization state, followed by magnetization to saturation and testing of the magnetic properties from the fully magnetized condition.

8.4.3 When magnets are being purchased in the unmagnetized condition or in an unknown state of magnetization, the test laboratory shall magnetize the test specimen(s) to saturation in the same orientation as the received specimens' indicated direction of magnetization and measure the magnetic properties from this fully magnetized condition.

8.4.4 When magnets are being purchased in a calibrated, stabilized, or "knocked-down" condition, magnets should be handled with care to prevent exposure to externally applied fields. Refer to [Appendix X3](#) for an explanation of these terms. During testing using Test Method [A977/A977M](#) and to avoid changing the magnetization state of the material prior to test, the measurement should proceed in the second quadrant only without attempting to saturate the magnet specimen.

8.4.5 Other test methods may be utilized as agreed to between producer and user. Such tests may include open circuit magnetization Helmholtz test (refer to [Appendix X3](#)), field strength measurements in a defined magnetic circuit or magnetic flux density measurements adjacent to the magnet surface.

8.4.6 Due to the ease with which the magnetic field of Alnico magnets can be affected, the producer and user should agree on methods to prevent unintended changes from occurring. These preventive measures may include the use of keepers across the magnet poles, spacing within packaging to prevent like poles from affecting each other, or other agreed-to methods.

9. Workmanship, Finish, and Appearance

9.1 Dimensions and tolerances shall be as specified on the magnet drawing and must be agreed upon between the producer and user.

9.2 Porosity and voids are common in Alnico magnets and shall not in themselves constitute reason for rejection unless agreed upon between producer and user. Allowable defects shall be defined and documented in writing as part of the ordering or contracting process.

9.3 Magnets shall be free of loose chips and surface residue which may interfere with assembly or proper device function.

9.4 Chips shall be acceptable if no more than 10 % of any surface identified as a magnetic pole surface is removed unless otherwise agreed to by producer and user.

9.5 Cracks visible to the naked eye shall not be permitted unless otherwise agreed to by producer and user.

10. Sampling

10.1 Unless otherwise agreed to between producer and user, a lot shall consist of parts of the same form and dimensions, produced from a single furnace melt (cast Alnico) or mixed powder batch or sintering run (sintered Alnico), and from an unchanged process, without discontinuity in production, and submitted for inspection at one time.

10.2 The producer and user shall agree upon a representative number of specimens for testing. Typically, a suitable number of parts, as mutually agreed upon between producer and user, shall be randomly selected from each lot. It is advisable to test a minimum of two parts from each lot, and more if there is reason to suspect that the magnetic properties are not uniform throughout the lot.

11. Rejection and Rehearing

11.1 Parts that fail to conform to the requirements of this specification shall be rejected. Rejection should be reported to the producer promptly and in writing. In case of dissatisfaction with the results of the test, the producer may make a claim for a rehearing.

11.2 The disposition of rejected parts shall be subject to agreement between the producer and user.

12. Certification

12.1 When specified in the purchase order or contract, the user shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and that the requirements have been met.

12.2 When specified in the purchase order or contract, a report of the test results shall include: