INTERNATIONAL

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Standard Specification for Soft Magnetic MnZn Ferrite Core Materials for Transformer and Inductor Applications[1]

This standard is issued under the fixed designation A1009; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the requirements to which the specified grades of soft magnetic manganese zinc (MnZn) ferrite materials shall conform. Cores made from these materials are used primarily in transformers and inductors.

1.2 *Frequency*—MnZn ferrite cores are primarily used for frequencies in the range of 10 kHz to 1 MHz. Many inductors have a DC component as well.

1.3 *Magnetic Flux Density*—Applications consist of two main categories, high and low magnetic flux density.

1.3.1 *High Magnetic Flux Density*—Transformers used for power conversion. Inductors or chokes used in high current applications.

1.3.2 *Low Magnetic Flux Density*—Transformers, inductors, chokes used for signal conditioning.

1.4 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.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A1013 Test Method for High-Frequency (10 kHz-1 MHz) Core Loss of Soft Magnetic Core Components at Controlled Temperatures Using the Voltmeter-Ammeter-Wattmeter Method

3. Terminology

3.1 The terms and symbols used in this specification are defined in Terminology A340.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air core inductance (L_{air})*—the A_L value, assuming an effective permeability of one. A_L is proportional to the factors of shape and size of the core. The air core inductance is expressed as nanohenries per turn squared (nH/N^2).

$$L_{air} = \mu_o A_e / L_e \quad (1)$$

where:

A_e = effective cross-sectional area of core in mm^2,
L_e = effective magnetic path length of core in mm, and
μ_o = the magnetic constant as 0.4 π nH/mm.

3.2.2 *effective initial permeability (μ_c)*—the initial permeability of the material as defined in A340, adjusted for known processing variables that are not accounted for in the L_{air} term such as mating surface finish and heat treatment. Can vary with size, shape, and material.

3.2.3 *inductance index (A_L value)*—the inductance normalized for the number of turns. Is proportional to the factors of effective initial permeability of the material core, shape, and size. It allows quick determination of expected inductance when used with the number of turns on the winding of the

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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.

intended application. The inductance index is expressed as nanohenries per turn squared (nH/N^2):

$$A_L = L_{air}\mu_e \quad (2)$$

And therefore the expected inductance (L) is:

$$L = A_L N^2 \quad (3)$$

where:

nH = inductance in nanohenries, 10^{-9} Henries,
N = the number of turns of winding,
L = the expected inductance, for a given A_L and number of turns.

3.2.4 *mated core set*—two or more core segments assembled with the magnetic flux path perpendicular to the mating surface.

4. Classification

4.1 The soft magnetic MnZn ferrite material-type designations for high and low magnetic flux density materials covered by this specification are listed in Table 1 and Table 2. The prefix of the type designations identifies each material's intended use. High magnetic flux density materials are denoted with the prefix P and low magnetic flux density materials are denoted with the prefix F.

4.2 *High Magnetic Flux Density Materials*—The first and second digits of the type designations identify the typical core loss density of the material in kW/m^3, and the remainder of the type designation identifies the temperatures in °C in which the core material must not exceed the maximum core loss density.

4.3 *Low Magnetic Flux Density Materials*—The last four digits of the type designations identify the typical relative inductance permeability.

5. Ordering Information

5.1 Orders for material under this specification shall include such of the following information as is required to describe the material adequately.

5.1.1 ASTM specification number including year of issue or revision.

5.1.2 ASTM soft magnetic MnZn ferrite material-type designation.

5.1.3 Core shape, size, dimensions, and dimensional tolerances.

5.1.4 Whether the core is to be purchased with or without a gap.

5.1.4.1 The Inductance Index (AL value) or the mechanical gap depth.

5.1.4.2 If the mated core set is ordered gapped by an Inductance Index (AL value), the purchaser must specify whether the mated core set consists of a gapped core half mated with an un-gapped core half or if both core halves are equally gapped.

5.1.4.3 If the mated core set is ordered gapped by an Inductance Index (AL value), the purchaser must supply the producer with a test coil and the testing conditions (circuit mode, turns on coil, frequency, and magnetic flux density).

5.1.4.4 The tolerance of either the Inductance Index (AL value) or the mechanical gap depth.

5.1.5 Quantity in pieces.

5.1.6 Exceptions to the specification or special requirements.

TABLE 1 High Magnetic Flux Density Material Type Designations and Magnetic Requirements

ASTM Power Material Type	Core Loss Density[A] kW/m^3 (mW/cm^3)		Temperature °C	Saturation Flux Density[B] mT (gauss)
	Nominal	Maximum		Minimum
P5025-100	50 (50)	65 (65)	25–100	500 (5000)
P5099	50 (50)	65 (65)	100	500 (5000)
P7070	70 (70)	80 (80)	70	500 (5000)
P7099	70 (70)	80 (80)	100	500 (5000)
P8040	80 (70)	90 (90)	40	500 (5000)

[A] Core loss density test conditions: 100 kHz, 100 mT (100 gauss), at specified temperature.
[B] Saturation flux density test conditions: 1 kHz, 1200 A/m (15 Oe), at 25°C.

TABLE 2 Low Magnetic Flux Density Material Type Designations and Magnetic Requirements

ASTM Filter Material Type	Relative Inductance Permeability[A] μ_L			
	Minimum	Nominal	Maximum	Tolerance
F010K	7000	10 000	13 000	±30 %
F7000	4900	7000	9100	±30 %
F5000	3750	5000	6250	±25 %
F3000	2500	3000	3750	±25 %

[A] Relative inductance permeability test conditions 100 kHz, 0.5 mT (5 gauss), at 25°C.

6. Magnetic Properties

6.1 *High Magnetic Flux Density Materials:*

6.1.1 *Core Loss*—The size of a MnZn ferrite core is often constrained by the core loss at the operating temperature. Each power material type is identified by a maximum core loss density limit at the temperatures where the core loss density is intended to be below this maximum limit as shown in Table 1.

6.1.2 *Saturation Flux Density*—The size of a MnZn ferrite core is often constrained by the saturation flux density. The minimum saturation flux density for each material is shown in Table 1.

6.2 *Low Magnetic Flux Density Materials:*

6.2.1 *Relative Inductance Permeability*—The size of a soft magnetic MnZn ferrite core is often constrained by the Inductance Index (AL value) which is dependent on the material permeability. Each material type is identified by its minimum and maximum relative inductance permeability as shown in Table 2.

7. Mechanical Properties

7.1 Typical material properties for soft magnetic MnZn ferrite materials are given in Table X1.1 of Appendix X1.

8. Dimensional Tolerances

8.1 For sintered (unground) dimensions, the tolerances shall be ±2.0 %.