Designation: A 1009 – 00

Standard Specification for Soft Magnetic MnZn Ferrite Core Materials for High Frequency (10 kHz-1 MHz) Power Transformer and Filter Inductor Applications[1]

This standard is issued under the fixed designation A 1009; 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 MnZn ferrite materials shall conform. Cores made from these materials are used primarily in power transformers and filter inductors.

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

2. Referenced Documents

2.1 *ASTM Standards:*

A 340 Terminology of Symbols and Definitions Relating to Magnetic Testing[2]

3. Terminology

3.1 The terms and symbols used in this specification are defined in Terminology A 340.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *Inductance Index (AL value)*—the self inductance per winding turn squared (L/N^2) expressed in units of nanohenries per turns squared (nH/N^2).

where:

n = nano = 10^{-9},
nH = inductance in nanohenries, and
N = number of turns on winding (example: 0.005 H with a 100 turn coil = $0.005/(100)^2$ H/N^2 = 500 nH/N^2).

3.2.2 *Mated Core Set*—Two or more core segments assembled with the magnetic flux path perpendicular to the mating surface.

3.2.3 Air core inductance, L_{air}, is the inductance of a core with the same magnetic path length and cross-sectional core area but with the relative permeability of air.

3.2.3.1 *Customary Units*

$$L_{air} = 4\Pi AN^2 10^{-9}/l_1, \text{ H}$$

where:

N = number of turns on winding;
A = cross-sectional area of core specimen, cm^2; and
l_1 = effective magnetic path length, cm.

3.2.3.2 *SI Units*

$$L_{air} = 4\Pi AN^2 10^{-7}/l_1, \text{ H}$$

where:

N = number of turns on winding;
A = cross-sectional area of core specimen, m^2; and
l_1 = effective magnetic path length, m.

4. Classification

4.1 The soft magnetic MnZn ferrite material-type designations for power transformer and filter inductor materials covered by this ASTM specification are listed in Table 1, Table 2, and Table X1.1. The prefix of the type designations identifies each material's intended use. Power transformer materials are denoted with the prefix "P" and filter materials are denoted with the prefix "F."

4.2 The first and second digits of the type designations for a power transformer material identify the typical core loss density of the material in mW/cm^3, and the last two digits identify the temperature of the minimum core loss in °C.

4.3 The last four digits of the type designations for filter materials 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.

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[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] *Annual Book of ASTM Standards*, Vol 03.04.

TABLE 1 Power Transformer Material Type Designations and Magnetic Requirements

ASTM Power Material Type	Maximum Core Loss Density at Temperature of Minimum Core Loss[A]		Temperature of Minimum Core Loss	Minimum Saturation Flux Density[B]	
	Customary Units, mW/cm^3	SI Units, W/m^3	SI Units, °C	Customary Units, Gauss	SI Units, Tesla
P5080	60	60 000	80	5000	0.5
P7070	80	80 000	70	5000	0.5
P7099	80	80 000	100	5000	0.5
P8040	90	90 000	40	5000	0.5

[A] Core loss test conditions: 100 kHz, 1000 gauss [0.1 tesla] at temperature of minimum core loss.

[B] Saturation flux density test conditions: 1 kHz, 15 oersteds [1200 A/m], at 25°C.

TABLE 2 Filter Inductor Material Type Designations and Magnetic Requirements

ASTM Filter Material Type	Minimum Relative Inductance Permeability,[A] μ_L	Maximum Relative Inductance Permeability,[A] μ_L
F010K	7000	13 000
F5000	3750	6 500
F3000	2250	3 900

[A] Relative inductance permeability test conditions: 100 kHz, 5 gauss [0.0005 tesla], at 25°C.

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 ungapped 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 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.

6. Magnetic Properties

6.1 The size of a soft magnetic MnZn ferrite power transformer core for relatively high frequencies (>50 kHz) is often constrained by the core loss at the operating temperature. A soft magnetic MnZn ferrite power transformer material type exhibits its minimum core loss density at a specific temperature. Each power material type is identified by a maximum core loss density limit at the temperature where the minimum core loss is intended to occur as shown in Table 1.

6.2 The size of a soft magnetic MnZn ferrite power transformer core for relatively low frequencies (<50 kHz) is often constrained by the saturation flux density. The minimum saturation flux density for each power material is shown in Table 1.

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

7. Mechanical Properties

7.1 Typical material constants for soft magnetic MnZn ferrite materials are given in Table X1.2 of Appendix X1.

8. Dimensional Tolerances

8.1 For sintered (unground) dimensions, the tolerances shall be ±2 %.

8.2 For machined heights, the tolerances shall be ±0.005 in. (0.13 mm).

9. Workmanship, Finish and Appearance

9.1 All mating surfaces of the core shall be free of dirt or any other foreign material. Foreign material or surface crazing that interfere mechanically or electrically are not allowed.

9.2 The largest dimension of a chip, crack, pit, or surface void must not exceed one third the smallest dimension of the surface under consideration.

10. Test Methods

10.1 Core losses are determined in accordance with the procedure of the proposed Test Method for High Frequency (10 kHz-1 MHz) Core Loss of Soft Magnetic Core Specimens at Controlled Temperatures Using the Voltmeter-Ammeter-Wattmeter Method.[3]

10.2 Flux densities are determined by calculating flux per unit core area from the integrated voltage measured on a secondary winding when the current through the primary winding is set for the desired magnetizing field strength.

10.3 Relative inductance permeability is determined by dividing the measured inductance by the air core inductance.

$$\mu_L = L / L_{\text{air}}$$

10.4 The inductance is typically measured using a digital LCR meter or equivalent. Procedures described by the manufacturer in the manuals of the LCR meter should be followed. See also 5.1.4.3.

10.5 The size and shape of the test core specimen is of the producer's choice but must have uniform cross-sectional core area throughout its magnetic path length and be ungapped.

11. Lot Identification

11.1 The producer shall assign a lot identification code that can be used to identify the specific raw material lots, moldable powder lot, kiln firing, and grinding lot.

12. Material Certification Report

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

[3] This test method is being developed by Committee A-6 on Magnetic Properties.

12.1.1 For power transformer materials, the producer shall include with each shipment a certified report of the core loss, sintered dimensions, and Inductance Index (AL value) or gap length.

12.1.2 For filter materials, the manufacturer shall include with each shipment a certified report of the Inductance Index (AL value).

12.2 The material certification report shall carry the lot identification.

13. Keywords

13.1 core loss density; high frequency magnetic materials; MnZn; permeability; soft ferrite materials

APPENDIX

(Nonmandatory Information)

X1. PROPERTIES

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned

TABLE X1.1 Typical Magnetic Properties for Power Transformer Materials

ASTM Power Material Type	Typical Core Loss Density at Temperature of Minimum Core Loss[A]		Temperature of Minimum Core Loss
	Customary Units, mW/cm^3	SI Units, W/m^3	SI Units, °C
P5080	50	50 000	80
P7070	70	70 000	70
P7099	70	70 000	100
P8040	80	80 000	40

[A]Core loss test conditions: 100 kHz, 1000 gauss [0.1 tesla] at temperature of minimum core loss.

TABLE X1.2 Physical and Mechanical Properties for Soft Magnetic MnZn Ferrite Typical Material Constants

Coefficient of linear expansion	$10 \times 10^{-6}/°C$
Tensile strength	7 ksi (50 MPa)
Compressive strength	60 ksi (410 MPa)
Density	$4.8\ g/cm^3$ ($4800\ kg/m^3$)