Designation: A1009 – 05 (Reapproved 2010)

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 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 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:*[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 *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 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 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 The last four digits of the type designations for filter materials identify the typical relative inductance permeability.

TABLE 1 Power Transformer Material Type Designations and Magnetic Requirements

ASTM Power Material Type	Maximum Core Loss Density[A]		Specified Temperatures That Core Loss Density Must Not Exceed Maximum	Minimum Saturation Flux Density[B]	
	Customary Units, mW/cm³	SI Units, W/m³	SI Units, °C	Customary Units, G	SI Units, T
P5025-100	65	65 000	25-100	5000	0.5
P5099	65	65 000	99	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 G (0.1 T) at temperature of minimum core loss.
[B] Saturation flux density test conditions: 1 kHz, 15 Oe (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 G (0.0005 T), at 25°C.

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 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. 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.

6.2 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).

8.3 For machined gap depths, the tolerances shall be ±0.0007 in. (0.017 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 Test Method A1013.

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.

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

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.