INTERNATIONAL STANDARD

IEC 61332

Second edition
2005-09

Soft ferrite material classification

Reference number
IEC 61332:2005(E)

Publication numbering

As from 1 January 1997 all IEC publications are issued with a designation in the 60000 series. For example, IEC 34-1 is now referred to as IEC 60034-1.

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE G

For price, see current catalogue

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SOFT FERRITE MATERIAL CLASSIFICATION

FOREWORD

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International Standard IEC 61332 has been prepared IEC technical committee 51: Magnetic components and ferrite materials.

This second edition cancels and replaces the first edition published in 1995. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the scope has been reviewed;
b) the column of temperature coefficient of SP class ferrite material has been omitted;
c) the measuring frequency for relative loss factor of SP class has been specified;
d) the parameters of SP class has been coordinated with IEC 60401-3.

The text of this standard is based on the following documents:

FDIS	Report on voting
51/832/FDIS	51/838/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

SOFT FERRITE MATERIAL CLASSIFICATION

1 Scope

This International Standard specifies classification rules for soft ferrite materials used in inductive components (inductors and transformers) fulfilling the requirements of the electronic industries.

This standard addresses the following purposes for ferrite suppliers and users:

– cross-reference between materials from multiple suppliers;
– assistance to customers in understanding the published technical data in catalogues when comparing multiple suppliers;
– guidance to customers in selecting the most applicable material for each application;
– setting of nomenclature for IEC standards relating to ferrite;
– establishing uniform benchmarks for suppliers for performance in new development of materials.

The numerical values given in this standard are typical values of parameters (properties) of the related materials. Direct translation from the material specification into the core specification is not always easy or possible.

Every detailed material and core specification should be agreed upon between the user and the manufacturer.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-221:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 221: Magnetic materials and components*

IEC 60401-3: 2003, *Terms and nomenclature for cores made of magnetically soft ferrites – Part 3: Guidelines on the format of data appearing in manufacturers' catalogues of transformer and inductor cores*

3 Terms and definitions

For the purposes of this document, the terms and definitions in Tables 1, 2 and 3 are defined in IEC 60050-221.

4 Classification

4.1 Material classification

Soft ferrite materials may be classified by the following basic parameters:

– initial permeability and the relevant operation frequency and/or applicable maximum frequency;
– initial permeability as a function of the temperature;
– applicable maximum flux density and/or amplitude permeability;
– power loss at a given frequency, temperature and flux density;
– normalized impedance at a given frequency.

4.2 Main classes

Soft ferrite materials may be divided into three main classes identified by two letters as follows:

- class IS materials are for use at a.c. low flux density as impedances in interference suppression (EMI) applications;
- class SP materials are for use at low flux density in signal processing applications;
- class PW materials are for use at high flux density (power application).

4.3 Subclasses

Each main class is divided into subclasses identified by two letters and a serial number.

Ferrite manufacturers' catalogues may indicate more than one class into which a material grade can fall, where desired.

5 Soft ferrite material classes

5.1 Materials used as impedances in interference suppression applications (IS class)

These materials are mainly used in the shape of rods, tubes, beads, wide band chokes, bobbin cores and rings. The relevant subclasses are given in Table 1.

Table 1 – IS class ferrite materials

Subclasses	Frequency[a)] MHz	Normalized impedance[b)] Z_N Ω/mm	Initial permeability[c)] μ_i	Curie temperature T_C °C
IS1	300	≥ 50	< 100	> 300
IS2a IS2b	300	≥ 50 ≥ 40	100 - 2 000	200 - 300
IS3a IS3b	100	≥ 40 ≥ 30	100 - 2 000	100 - 250
IS4a IS4b	30	≥ 30 ≥ 20	100 - 2 000	100 - 250
IS5a IS5b	10	≥ 30 ≥ 20	2 000 - 6 000	100 - 250
IS6a IS6b	3	≥ 30 ≥ 20	2 000 - 6 000	100 - 150
IS7a IS7b	1	≥ 20 ≥ 10	2 000 - 6 000	100 - 150
IS8a IS8b	1	≥ 20 ≥ 10	6 000 - 10 000	100 - 150
IS9a IS9b	0,5	≥ 10 ≥ 5	10 000 - 15 000	> 100

a) The frequency is the measuring frequency of the normalized impedance.

b) Measured on a bead ϕ5 mm × ϕ2 mm × 10 mm and at temperature of 25°C.

c) μ_i is measured at ≤ 10 kHz, ≤ 0,5 mT. μ_i is for reference only, indicating typical values seen. μ_i is not a fundamental parameter for class IS materials.

5.2 Materials used mainly in low flux density applications (B ≤ 5 mT) (SP class)

These materials are mainly used in the shape of ring-cores, pot-cores, EP-cores, RM-cores and E-cores. The relevant subclasses are given in Table 2.

Table 2 – SP class ferrite materials

Subclasses	Initial permeability[a] μ_i	Relative loss factor[a] $\tan\delta/\mu_i$ $\times 10^{-6}$	Frequency[b] MHz	Curie temperature T_C °C
SP1	< 100	50 - 150	10	> 300
SP2	100 - 400	20 - 30	1	> 250
SP3	400 - 800	15 - 50	0,1	> 150
SP4	800 - 1 200	1 - 10	0,1	> 120
SP5	1 200 - 2 000	1 - 10	0,1	> 120
SP6	1 200 - 2 500	2 - 7	0,1	> 150
SP7	1 500 - 2 500	3 - 5	0,1	> 150
SP8	2 500 - 3 500	2 - 10	0,1	> 130
SP9	3 500 - 6 000	≤ 15	0,1	> 120
SP10a SP10b	6 000 - 8 000 6 000 - 8 000	≤ 3 ≤ 10	0,01 0,01	> 120 > 120
SP11a SP11b	8 000 - 12 000 8 000 - 12 000	≤ 3 ≤ 10	0,01 0,01	> 100 > 100
SP12a SP12b	12 000 - 16 000 12 000 - 16 000	≤ 6 ≤ 20	0,01 0,01	> 100 > 100
SP13	16 000 - 20 000	≤ 20	0,01	> 100

[a] μ_i and $\tan\delta/\mu_i$ are measured at 25°C.

[b] The frequency is the measuring frequency for $\tan\delta/\mu_i$.

NOTE Size of the test core is ϕ10 mm × ϕ6 mm × 4 mm.

5.3 Materials used mainly in high flux density applications (PW class)

These materials are mainly used in the shape of RM-cores, EFD-cores, ER-cores, ETD-cores, EER-cores, E-cores, PQ-cores, ring-cores and cores for planar applications. The relevant subclasses are given in Table 3.

Table 3 – PW class ferrite materials

Subclasses	f_{max} [a)] kHz	f [c)d)] kHz	B [b)] mT	μ_a [c)]	Performance factor ($B \times f$) mT × kHz	Power loss (volume) density[d) e) f)] kW/m^3	μ_i [g)]
PW1a PW1b PW1c	100	15	300	2 500	4 500 (300 × 15)	≤ 100 ≤ 200 ≤ 300	3 500 - 2 000
PW2a PW2b PW2c	200	25	200	2 500	5 000 (200 × 25)	≤ 60 ≤ 150 ≤ 300	3 500 - 2 000
PW3a PW3b PW3c	300	100	100	3 000	10 000 (100 × 100)	≤ 60 ≤ 150 ≤ 300	3 500 - 2 000
PW4a PW4b PW4c	500	300	50	3 000	15 000 (50 × 300)	≤ 100 ≤ 150 ≤ 300	2 000 - 1 400
PW5a PW5b PW5c	1 000	500	50	2 000	25 000 (50 × 500)	≤ 100 ≤ 150 ≤ 300	2 000 - 1 400
PW6a PW6b PW6c	2 000	1 000	25	1 000	25 000 (25 × 1 000)	≤ 100 ≤ 150 ≤ 300	1 400 - 800
PW7a PW7b PW7c	3 000	2 000	15	1 000	30 000 (15 × 2 000)	≤ 100 ≤ 150 ≤ 300	1 400 - 800
PW8a PW8b PW8c	5 000	3 000	10	400	30 000 (10 × 3 000)	≤ 100 ≤ 200 ≤ 300	800 - 400
PW9a PW9b	10 000	5 000	10	40	50 000 (10 × 5 000)	≤ 200 ≤ 300	400 - 40

a) f_{max} is the guide of the applicable maximum frequency relevant to a given material subclass.

b) B is the applicable a.c. peak flux density relevant to a given material subclass. These levels of B are normally resulting in power losses in the ranges of ≤ 300 kW/m^3. In these ranges a wide variety of sizes in the common shapes can be used in open-air conditions without forced cooling. The use of higher flux densities in these subclasses will result in higher power losses, which may often require additional cooling, or will be limited in open air with no forced cooling to the use of only smaller sizes from the common core shapes.

c) μ_a is the amplitude permeability at 100 °C, B and f in Table 3. μ_a is for reference only.

d) Power loss should be measured at 100 °C, B and f in Table 3. These combinations of B and f are different from the preferred combinations according to IEC 60401-3, Table 2, where power losses higher than 300 kW/m^3 are assumed as well (see also b)).

e) Power loss only refers to B as an a.c. peak flux density and dose not apply for situations where there is a combination of a.c. and d.c. flux density applicable in which power losses may be different. In these cases, it is usual that a critical parameter used for core selection is either

1) saturation flux density at the intended maximum operating temperature (typically 100 °C to 120 °C); or

2) maximum decrease in inductance with a specified d.c. flux density, a.c. flux density, temperature, and air gap in the core structure (the gap is defined by dimension or by inductance factor).

f) Power loss only refers to the temperature of 100 °C, although there are some power ferrites available which are optimised for lower or higher operating temperatures than approximately 100 °C.

g) μ_i is measured at ≤ 10 kHz, ≤ 0,5 mT. μ_i is for reference only, indicating typical values seen. μ_i is not a fundamental parameter for class PW materials.

NOTE Size of the test core is ϕ25 mm × ϕ15 mm × 10 mm.

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ISBN 2-8318-8218-4

ICS 29.100.10

Typeset and printed by the IEC Central Office
GENEVA, SWITZERLAND