# IEC 61332

Edition 3.0 2016-11

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

## Soft ferrite material classification

## Classification des matériaux ferrites doux



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# SOFT FERRITE MATERIAL CLASSIFICATION

## FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61332 has been prepared IEC technical committee 51: Magnetic components, ferrite and magnetic powder materials.

This third edition cancels and replaces the second edition published in 2005. This edition constitutes a technical revision.

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

a) deleted "c" rank from subclass from Table 3, because of too large power loss density;
b) added "a-wide" rank in subclasses PW3, PW4 and PW5 in Table 3;
c) changed "$B$" of PW3 class from 100 mT to 200 mT; "$B \times f$" and "power loss density" have also been changed;
d) changed "$B$" of PW4 class from 50 mT to 100 mT; "$B \times f$" and "power loss density" have also been changed.

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

| FDIS | Report on voting |
|---|---|
| 51/1146/FDIS | 51/1155/RVD |

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

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

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

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

# SOFT FERRITE MATERIAL CLASSIFICATION

## 1 Scope

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

This document addresses the following issues 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 document are typical values of the 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 documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *International Electrotechnical Vocabulary – Chapter 221: Magnetic materials and components*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-221 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

# 4 Classification

## 4.1 Material classification

Soft ferrite materials may be classified according to the following basic parameters:

- initial permeability and 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 AC 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]<br>MHz | Normalized impedance[b]<br>$Z_N$<br>Ω/mm | Initial permeability[c]<br>$\mu_i$ | Curie temperature<br>$T_C$<br>°C |
|---|---|---|---|---|
| IS1 | 300 | ≥ 50 | < 100 | > 300 |
| IS2a<br>IS2b | 300 | ≥ 50<br>≥ 40 | 100 to 2 000 | 200 to 300 |
| IS3a<br>IS3b | 100 | ≥ 40<br>≥ 30 | 100 to 2 000 | 100 to 250 |
| IS4a<br>IS4b | 30 | ≥ 30<br>≥ 20 | 100 to 2 000 | 100 to 250 |
| IS5a<br>IS5b | 10 | ≥ 30<br>≥ 20 | 2 000 to 6 000 | 100 to 250 |
| IS6a<br>IS6b | 3 | ≥ 30<br>≥ 20 | 2 000 to 6 000 | 100 to 150 |
| IS7a<br>IS7b | 1 | ≥ 20<br>≥ 10 | 2 000 to 6 000 | 100 to 150 |
| IS8a<br>IS8b | 1 | ≥ 20<br>≥ 10 | 6 000 to 10 000 | 100 to 150 |
| IS9a<br>IS9b | 0,5 | ≥ 10<br>≥ 5 | 10 000 to 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 a temperature of 25 °C.

[c] $\mu_i$ is measured at ≤ 10 kHz, ≤ 0,5 mT. $\mu_i$ is for reference only, indicating typical values seen. $\mu_i$ 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]<br><br>$\mu_i$ | Relative loss factor[a]<br>$\tan\delta/\mu_i$<br>$\times 10^{-6}$ | Frequency[b]<br><br>MHz | Curie temperature<br>$T_C$<br>°C |
|---|---|---|---|---|
| SP1 | < 100 | 50 to 150 | 10 | > 300 |
| SP2 | 100 to 400 | 20 to 30 | 1 | > 250 |
| SP3 | 400 to 800 | 15 to 50 | 0,1 | > 150 |
| SP4 | 800 to 1 200 | 1 to 10 | 0,1 | > 120 |
| SP5 | 1 200 to 2 000 | 1 to 10 | 0,1 | > 120 |
| SP6 | 1 200 to 2 500 | 2 to 7 | 0,1 | > 150 |
| SP7 | 1 500 to 2 500 | 3 to 5 | 0,1 | > 150 |
| SP8 | 2 500 to 3 500 | 2 to 10 | 0,1 | > 130 |
| SP9 | 3 500 to 6 000 | ≤ 15 | 0,1 | > 120 |
| SP10a<br>SP10b | 6 000 to 8 000<br>6 000 to 8 000 | ≤ 3<br>≤ 10 | 0,01<br>0,01 | > 120<br>> 120 |
| SP11a<br>SP11b | 8 000 to 12 000<br>8 000 to 12 000 | ≤ 3<br>≤ 10 | 0,01<br>0,01 | > 100<br>> 100 |
| SP12a<br>SP12b | 12 000 to 16 000<br>12 000 to 16 000 | ≤ 6<br>≤ 20 | 0,01<br>0,01 | > 100<br>> 100 |
| SP13 | 16 000 to 20 000 | ≤ 20 | 0,01 | > 100 |



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

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

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



## 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]<br>kHz | $f$ [c,d]<br>kHz | $B$ [b]<br>mT | $\mu_a$ [c] | $T$<br>°C | Performance factor<br>$(B \times f)$<br>mT×kHz | Power loss (volume)<br>Density [d,e,f]<br>kW/m³ | $\mu_i$ [g] |
|---|---|---|---|---|---|---|---|---|
| PW1a<br>PW1b | 100 | 15 | 300 | 2 500 | 100 | 4 500<br>(300×15) | ≤ 100<br>≤ 200 | 3 500 to 2 000 |
| PW2a<br>PW2b | 200 | 25 | 200 | 2 500 | 100 | 5 000<br>(200×25) | ≤ 60<br>≤ 150 | 3 500 to 2 000 |
| PW3a<br>PW3b<br>PW3a-wide | 300 | 100 | 200 | 3 000 | 100<br>100<br>80 to 140 | 20 000<br>(200×100) | ≤ 350<br>≤ 700<br>≤ 450 | 3 500 to 2 000 |
| PW4a<br>PW4b<br>PW4a-wide | 500 | 300 | 100 | 3 000 | 100<br>100<br>60 to 120 | 30 000<br>(100×300) | ≤ 350<br>≤ 700<br>≤ 350 | 3 000 to 1 400 |
| PW5a<br>PW5b<br>PW5a-wide | 1 000 | 500 | 50 | 2 000 | 100<br>100<br>60 to 120 | 25 000<br>(50×500) | ≤ 100<br>≤ 150<br>≤ 150 | 2 000 to 1 400 |
| PW6a<br>PW6b | 2 000 | 1 000 | 25 | 1 000 | 100 | 25 000<br>(25×1 000) | ≤ 100<br>≤ 150 | 1 400 to 800 |
| PW7a<br>PW7b | 3 000 | 2 000 | 15 | 1 000 | 100 | 30 000<br>(15×2 000) | ≤ 100<br>≤ 150 | 1 400 to 800 |
| PW8a<br>PW8b | 5 000 | 3 000 | 10 | 400 | 100 | 30 000<br>(10×3 000) | ≤ 100<br>≤ 200 | 800 to 400 |
| PW9a<br>PW9b | 10 000 | 5 000 | 10 | 40 | 100 | 50 000<br>(10×5 000) | ≤ 200<br>≤ 300 | 400 to 40 |

NOTE The size of the test core is ϕ25 mm × ϕ15 mm × 10 mm or smaller.



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

[b] $B$ is the applicable AC peak flux density relevant to a given material subclass. These levels of $B$ normally result in power losses in the ranges ≤ 300 kW/m³. 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] $\mu_a$ is the amplitude permeability at the conditions of $T$, $B$ and $f$ in Table 3. $\mu_a$ is for reference only.

[d] Power loss should be measured at the conditions of $T$, $B$ and $f$ in Table 3. These combinations of $B$ and $f$ are different than the preferred combinations according IEC 60401-3:2015, Table 2, where higher power losses than 300 kW/m³ are assumed as well (see also footnote b above).

[e] Power loss is only referring to $B$ as AC peak flux density and does not apply to situations where there is a combination of AC and DC 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) a saturation flux density at the intended maximum operating temperature (typically 100 °C to 120 °C); or
2) a maximum decrease in inductance with a specified DC flux density, AC flux density, temperature, and air gap in the core structure (the gap is defined by the dimension or by the 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 about 100 °C.

[g] $\mu_i$ is measured at ≤ 10 kHz, ≤ 0,5 mT. $\mu_i$ is for reference only, indicating typical values seen. $\mu_i$ is not a fundamental parameter for class PW materials.