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# Magnetic materials — Specification for sintered soft magnetic materials

The European Standard EN 10331:2003 has the status of a  
British Standard

ICS 29.030





## National foreword

This British Standard is the official English language version of EN 10331:2003. It supersedes BS 6404-8.9:1995 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/NFE/5, Magnetic alloys and steels, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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**Summary of pages**

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 9 and a back cover.

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### Amendments issued since publication

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English version

## Magnetic materials - Specification for sintered soft magnetic materials

Matériaux magnétiques - Spécification des matériaux magnétiques doux frittés

Magnetische Werkstoffe - Anforderungen an weichmagnetische Sintermetalle

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## Foreword

This document (EN 10331:2003) has been prepared by Technical Committee ECISS/TC 24, "Electrical steel sheet and strip qualities - Qualities dimensions, tolerances and specific tests", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2003, and conflicting national standards shall be withdrawn at the latest by October 2003.

This document is equivalent to IEC 60404-8-9.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

## 1 Scope

This European Standard specifies some magnetic and mechanical properties of sintered soft magnetic metals which are used for components made by a powder metallurgical process only.

This standard does not apply to magnetically soft castings or to semi-finished products.

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

prEN 10281, Magnetic materials – Methods of measurement of the magnetic properties of isotropic nickel-iron soft magnetic alloys, types E1, E3 and E4.

EN 24498-1, Sintered metal materials, excluding hardmetals - Determination of apparent hardness - Part 1: Materials of essentially uniform section hardness (ISO 4498-1:1990)

IEC 60050-121:1998, International Electrotechnical Vocabulary (IEV) – Chapter 121: Electromagnetism.

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

EN ISO 2738, Sintered metal materials, excluding hardmetals - Permeable sintered metal materials – Determination of density, oil content and open porosity (ISO 2738:1999).

ISO 3369, Impermeable sintered metal materials and hardmetals – Determination of density.

ISO 4498-2, Sintered metal materials, excluding hardmetals – Determination of apparent hardness – Part 2: Case-hardened ferrous materials, surface enriched by carbon or carbon and nitrogen

ISO 5755, Sintered metal materials – Specifications.

## 3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in IEC 60050-121:1998 and IEC 60050-221:1990, and the following apply:

### 3.1

#### sintered density,

quotient of mass  $m$  and volume  $V$  of the sintered structural part (including pores) :

$$\rho_s = \frac{m}{V} \quad (1)$$

NOTE The sintered density  $\rho_s$ , given in equation (1) in grammes per cubic centimetres, is calculated from  $m$  in grammes and  $V$  in cubic centimetres.

### 3.2 porosity,

$P_s$

content of pores relative to the total volume of the part in volume per cent

NOTE 1 Porosity of the sintered metal with the sintered density is calculated as follows:

$$P_s = (1 - \rho_s / \rho) \times 100 \% \quad (2)$$





Where

$\rho$  is the density of the solid (theoretical density) of the same composition.

NOTE 2 The porosity  $P_s$  of a sintered metal consists of open, interconnected and closed pores. In the case of high sintered densities (corresponding to a porosity of approximately 6 %) isolated (closed) pores become predominant.

## 4 Symbols

For the purposes of this standard, the following symbols apply:

$H$  Magnetic field strength;

$J$  Magnetic polarization;

$P_s$  Porosity;

$\rho_s$  Sintered density.

## 5 General requirements

### 5.1 Manufacturing process

The magnetically soft structural parts defined by this standard are manufactured by a powder metallurgical process. Unless otherwise agreed, the manufacturing process is left to the discretion of the manufacturer.

### 5.2 State of delivery

Unless otherwise agreed, the products are delivered in the finally annealed state.

### 5.3 Properties

The maximum values of coercivity and the minimum values of sintered density shall be as given in Table 1. Table 2 includes typical values for additional properties.

Values of the other properties of components, such as mechanical strength and surface finish (including protection against corrosion), can be agreed upon between manufacturer and purchaser.

### 5.4 Chemical composition

Data relating to the typical content of characteristic alloying elements of sintered metals are given in Table 2. The values of chemical composition are not specified for acceptance.

### 5.5 Dimensions

The permissible dimensional values of components and their tolerances form an integral part of the agreement between manufacturer and purchaser.

## 6 Measurements

### 6.1 Scope of test and sampling

For the purpose of delivery the scope of tests and the method of sampling to verify the properties shall be agreed when the order is placed.

## 6.2 Determination of magnetic properties

### 6.2.1 General

It shall be ensured that specimen is in the finally annealed state and not in the cold worked state. The values given in this standard are specified for ring-shaped samples.

Magnetic properties measured on components may be different due to geometry or to test method.

NOTE If required these properties may be subject to agreement between manufacturer and purchaser.

### 6.2.2 Method for the determination of coercivity

Coercivity as specified in Table 1 shall be measured in accordance with prEN 10281. EN 10330 may be used for other shapes.

### 6.2.3 Method for the determination of magnetic polarization

The typical values as given in Table 2 have been determined on ring-shaped samples. Other samples (for example strips or rods) may lead to different results.

The test method is described in prEN 10281.

## 6.3 Determination of density

For the determination of density, the components shall be weighed and their volume determined on the basis of geometric dimensions or by means of the immersion method in accordance with EN ISO 2738 or ISO 3369.

## 6.4 Determination of hardness

Hardness of the components, as given in Table 2, is determined according to the Vickers method in accordance with EN 24498-1 and ISO 4498-2. The Brinell method in accordance with EN ISO 6506-1 may also be used.

## 7 Classification

The materials covered by this standard are classified according to the maximum value of their coercivity.

## 8 Designation

The conventional designation of the different grades comprises the following in the order given :

- 1) the identification letter S (sintered metal) ;
- 2) a dash ;
- 3) letters characterising the alloying elements (Fe = plain iron, FeP = phosphorous iron alloys, FeSi = silicon iron alloys, FeNi = nickel iron alloys, FeCo = cobalt iron alloys) ;
- 4) a code number equal to the maximum value of coercivity, corresponding to Table 1. In this Table, reference is also made to corresponding material defined in ISO 5755.

## 9 Ordering information

For materials to comply adequately with the requirements of this standard, the purchaser shall include the following information in his enquiry or order:

- a) nature of the product and the designation of the material in accordance with clause 8 ;
- b) where applicable, its dimensions (see 5.5) ;
- c) quantity required ;
- d) scope of tests and method of sampling (see 6.1) ;
- e) following additional requirements shall be specified at the time of enquiry and order. If nothing is specified the manufacturer shall assume that there are no particular requirements on these points :

other properties (see 5.3) ;

other shapes of test specimen (see 6.2) ;

other methods of test (see 6.2.3).

**Table 1 — Minimum sintered densities and maximum coercivities**

Material symbolic designation	Material designation according to ISO 5755	Density  <sup>3</sup> g/cm min.	Coercivity <i>H<sub>c</sub></i> A/m max.
S-Fe-175	P 1024 Z	6,4	175
S-Fe-170	P 1025 Z	6,8	170
S-Fe-165	-	7,1	165
S-Fe-150 <sup>a</sup>	-	7,3	150
S-FeP-150	-	6,8	150
S-FeP-130	-	7,1	130
S-FeP-110 <sup>a</sup>	-	7,3	110
S-FeSi-80	-	7,2	80
S-FeSi-50	-	7,4	50
S-FeNi-20	-	7,6	20
S-FeNi-15	-	7,9	15
S-FeNi-8	-	8,3	8
S-FeCo-100	-	7,7	100
S-FeCo-200	-	7,7	200
<sup>a</sup> With special precautions in the processing a lower coercivity is possible : 100 A/m for S-Fe-150 and 60 A/m for S-FeP-110.			

Table 2 — Typical values for the properties of soft magnetic sintered materials in the finally annealed state<sup>a</sup>

Material designation	Characteristic alloying elements (except Fe) % by mass	Sintered density $\rho_s$ g/cm <sup>3</sup>	Porosity $P_s$ %	Magnetic polarization (T) at a field strength $H$ (A/m) of			Maximum permeability $\mu_{max}$	Vickers hardness	Resistivity
				500	5 000	15 000			
S-Fe-175		6,6	16	0,70	1,10	1,40	1,55	50	0,15
S-Fe-170		7,0	11	0,90	1,25	1,45	1,65	60	0,13
S-Fe-165		7,2	9	1,10	1,40	1,55	1,75	70	0,12
S-Fe-150 <sup>c</sup>		7,4	6	1,30	1,55	1,70	1,85	70	0,12
S-FeP-150	approx 0,45 % P	7,0	10	1,05	1,30	1,50	1,65	95	0,20
S-FeP-130	0,45 % P	7,2	8	1,20	1,45	1,60	1,75	105	0,19
S-FeP-110 <sup>c</sup>	0,45 % P	7,4	5	1,35	1,60	1,75	1,85	100	0,18
S-FeSi-80	approx 3,0 % Si	7,3	4	1,35	1,55	1,70	1,85	170	0,45
S-FeSi-50	3,0 % Si	7,5	2	1,40	1,65	1,70	1,95	180	0,45
S-FeNi-20	approx 50 % Ni	7,7	7	1,10	1,25	1,30	1,30	70	0,50
S-FeNi-15	50 % Ni	8,0	4	1,30	1,50	1,55	1,55	85	0,45
S-FeNi-8	approx 80 % Ni + Mo	8,4	3	0,75 <sup>d</sup>	0,80	0,80	0,80	95	0,60
S-FeCo-200	approx 50 % Co	7,8	3	1,55	2,05	2,15	2,20	240	0,35
S-FeCo-100	50 % Co	7,8	3	1,50	2,00	2,10	2,15	190	0,10

<sup>a</sup> Some of these compositions are also available in resin-bonded components, which with reduced magnetic properties, but also with reduced losses, are used in high-frequency applications.

<sup>b</sup> Magnetic polarization at a field of 80 000 A/m corresponds to the saturation magnetic polarization.

<sup>c</sup> By special precautions in processing, lower values for the coercivity are possible.

<sup>d</sup> Magnetic polarization for S-FeNi-8 at a field strength of 40 A/m is 0,55 T.

## **Bibliography**

EN 10330, Magnetic materials – Method of measurement of the coercivity of magnetic materials in an open circuit.

EN ISO 6506-1, Metallic materials – Brinell Hardness test – Part 1: Test method (ISO 6506-1:1999).

IEC 60404-4, Magnetic materials – Part 4: Methods of measurement of d.c. magnetic properties of iron and steel.



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