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**Nickel iron soft magnetic
metallic materials**

ICS 29.030

Descriptors : magnetic cores, electric screens, iron, nickel, magnetic alloys, sheet materials, strips, electronic equipment and components, bars (materials), wires

Reference number : JIS C 2531 : 1999 (E)

C 2531 : 1999

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS C 2531 : 1987** is replaced with **JIS C 2531 : 1999**.

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In the event of any doubts arising as to the contents,
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Nickel iron soft magnetic metallic materials

Introduction This Japanese Industrial Standard has been prepared based on IEC 60404-8-6, *Magnetic materials Part 8 : Specifications for individual materials Section six—Soft magnetic metallic materials* published in 1986 as the first edition and IEC 60404-6, *Magnetic materials Part 6 : Methods of measurement of the magnetic properties of isotropic nickel-iron soft magnetic alloy E1, E3 and E4* published in 1986 as the first edition without modifying the technical contents for the corresponding parts (classification and magnetic grade, quality, etc.). However, it also specifies the classification and magnetic grades and associated quality formerly specified in JIS. As for the dimensional tolerances, the specification contained in the corresponding International Standard is altered.

1 Scope This Japanese Industrial Standard specifies the nickel iron alloy bars (hereafter referred to as “bars”), the alloy rod (hereafter referred to as “rods”), the alloy wires (hereafter referred to as “wires”), the alloy sheets (hereafter referred to as “sheets”) and the alloy strips (hereafter referred to as “strips”) which are used for various magnetic cores and magnetic shields in electronic equipment.

Remarks : The International Standards corresponding to this Standard are given below.

IEC 60404-8-6 : 1986 *Magnetic materials Part 8 : Specifications for individual materials Section six—Soft magnetic metallic materials*

IEC 60404-6 : 1986 *Magnetic materials Part 6 : Methods of measurement of the magnetic properties of isotropic nickel-iron soft magnetic alloy E1, E3 and E4*

Informative reference : The above IEC Standard numbers are based on the new numbering system of IEC Standards put in force on January 1st 1997, and the standard published before the said date is numbered by adding 60000 to the former number. This is the change in the number only, and the contents remain unchanged.

2 Definitions For the purpose of this Standard the following principal definitions shall apply:

- a) **absolute permeability** The quantity which expresses easiness of magnetizing nickel iron soft magnetic alloys. The quantifier is μ , the unit is henry per meter (H/m).

Absolute permeability μ multiplied by magnetic field strength H equals magnetic flux density B .

$$B = \mu H$$

where, B : magnetic flux density (T)
 H : magnetic field strength (A/m)
 μ : absolute permeability (H/m)

- b) **relative permeability** The absolute permeability μ divided by the permeability of vacuum $\mu_0 (= 4\pi \times 10^{-7} \text{ H/m})$. The unit is absolute number.
- c) **initial relative permeability** The ratio of flux density which is the inclination of the straight line connecting the original point (erased state) and a point close to the original point to the magnetic field strength divided by the permeability of vacuum $\mu_0 (= 4\pi \times 10^{-7} \text{ H/m})$. The symbol is μ_i , and the unit is absolute number.

The strength of d.c. magnetic field shall be 0.4 A/m, 0.8 A/m and 1.6 A/m.

- d) **magnetic flux density** The magnetic flux per unit area of a material when external magnetic field H is applied. The symbol is B_H , and the unit is tesla (T).

The H shall be 20, 50, 100, 500, 800 and 4 000 (A/m).

- e) **remanent magnetic flux density** The magnetic flux density at the time of removal of an external magnetic field of 800 A/m being applied. The symbol is B_r , and the unit is tesla (T).
- f) **squareness ratio** The remanent magnetic flux density divided by the magnetic flux density B_H .
- g) **coercive field strength** The magnetic field strength at which the magnetic flux density in a material becomes zero when an external magnetic field of 800 A/m applied to the material is removed and the material is magnetized in opposite direction. The symbol is H_c , and the unit is ampere per meter (A/m).
- h) **inductance relative permeability** The relative permeability obtained by calculation from the self inductance which appears when an a.c. current is passed through a winding on a closed magnetic core where the leakage current is negligible. The symbol is μ_L , and the unit is absolute number.
- i) **impedance relative permeability** The relative permeability obtained by calculation from the voltage (corresponding to magnetic flux density) generated on the secondary side due to the mutual inductance when an a.c. current (corresponding to magnetizing force) is passed through the primary winding on a closed magnetic core where the leakage magnetic flux is negligible. The symbol is μ_z , and the unit is absolute number.
- j) **impedance relative permeability rise factor** This factor expresses the degree of increase in permeability resulting from the increase in the magnetic field strength. The symbol is δ , and the unit is meter per ampere (m/A).
- k) **ageing** The relative change in coercive field strength after the specimen is heated at $100^\circ\text{C} \pm 5^\circ\text{C}$ for 100 h. This is expressed as a percent (%).
- l) **bar** Solid product of uniform cross-section supplied in straight lengths. The cross-section may be round, square, rectangular, or regular polygonal.
 - **flat** A bar of rectangular cross-section rolled on the four faces whose thickness is generally 5 mm or greater and whose width is less than 150 mm.
 - **round** A bar which has a round cross-section with a diameter 8 mm or greater.

- m) **rods** Cold-drawn product of uniform rectangular or round cross-section, supplied in straight lengths.
- n) **wire** Rolled or drawn product of uniform round or rectangular cross-section, supplied in coils.
- o) **sheet and plate** Flat rolled product of uniform cross-section, supplied in coils or cut lengths. The width exceeds 600 mm, and the one with a thickness not exceeding 5 mm is called a "sheet", and the one with a thickness exceeding 5 mm is called a "plate".
- p) **strip** Flat-rolled product of uniform cross-section, a width not exceeding 600 mm and a thickness not exceeding 5 mm which is supplied in coils or cut lengths.
- q) **lot** Material from the same heat, of the same form produced at the same time and, if annealed, heat-treated together or sequentially in a continuous furnace.
- r) **edge camber** The maximum value of the ratio of the depth e to the reference length L of a sheet, plate or strip.

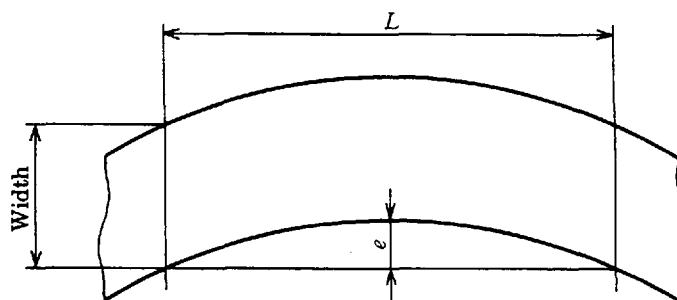


Fig. 1 Example of edge camber

- s) **flatness** The wave factor (wave height h /wave length L) of a sheet, plate or strip.

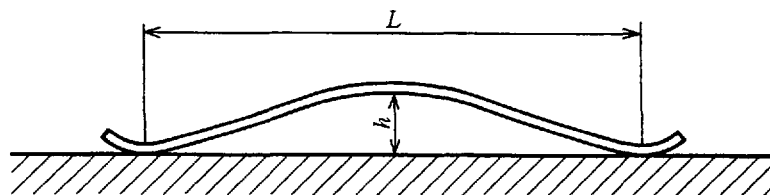


Fig. 2 Example of flatness

- t) **straightness of long products** The maximum value of the ratio of the depth of arc to the reference length of a bar.

Remarks : In the following clauses, "relative permeability" is customarily expressed as "permeability".

3 Classification and magnetic grading The classification shall be, according to the nickel content and the shape of hysteresis curve, as stated in Table 1.

The magnetic grading is according to the shape of hysteresis curve and the impedance permeability μ_z of S.W. type (strip wound toroidal) ring test specimen with a thickness of 0.1 mm (see 6.2.1).

Table 1 Classification

Classification	IEC classification ⁽¹⁾	Nickel content %	Informative reference					
			Representative chemical constituents %					Speciality and usage
			Cr	Cu	Mo	Ni	Fe	
PB	—	41 to 51	—	—	—	42 to 49	Remainder	High flux density materials, relays, transformers, etc.
—	E31	45 to 50	—	—	—	45 to 49	Remainder	
PC	—	70 to 85	2 to 3 — —	4 to 6 1 to 6	— 3 to 5 3.5 to 6	75 to 78 75 to 80 79 to 82	Remainder	High permeability materials, transformers, magnetic shields, wound cores, magnetic heads, etc.
—	E11	72 to 83	2 to 3 — —	4 to 6 4 to 6 —	— 3 to 4.5 3.5 to 6	75 to 78 75 to 78 79 to 82	Remainder	
PD	E41	35 to 40	—	—	—	36 to 40	Remainder	High resistance materials, transformers, etc.
PE	—	41 to 51	—	—	—	42 to 49	Remainder	High squareness ratio hysteresis materials, wound cores, transformers, etc.
—	E32	45 to 50	—	—	—	45 to 49	Remainder	
PF	E2	54 to 68	—	—	—	54 to 65	Remainder	Wound cores, transformers, etc.

Note (1) The second digit of IEC classification denotes the shape of hysteresis curve.
1 = Low square ratio 2 = High square ratio

The actual chemical constitution, square ratio and manufacturing process are subject to agreement between the parties concerned.

4 Quality

4.1 Appearance The nickel iron soft magnetic material shall be finished good and uniform, and shall be free from scratches, cracks and other defects detrimental to use.

4.2 Magnetic characteristics The magnetic characteristics shall be as stated in a) or b) given below. The magnetic characteristics mean those after the heat treatment. The conditions of heat treatment may be agreed between the parties concerned with acceptance.

a) **D.C. magnetic characteristics** The d.c. magnetic characteristics (initial permeability, coercive field strength and magnetic flux density) shall be as stated in Table 2.