

Specification for

Nickel-iron transformer and choke laminations

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- British Steel Corporation
- Engineering Equipment Users' Association
- National Supervising Inspectorate
- Sheet Makers' Conference
- Telephone Manufacturers Technical Development Committee
- Transmission Distribution Association
- United Kingdom Atomic Energy Authority

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Foreword

This British Standard was originally published in 1957 under the authority of the Iron and Steel Industry Standards Committee. This revised edition has been prepared under the authority of the Telecommunication Industry Standards Committee. New lamination ranges (based on IEC; recommendations) and requirements for additional magnetic characteristics are included; the requirements for the permeability of laminations and the description of suitable test methods are more comprehensively treated; and opportunity has been taken to give metric values of the dimensions of laminations.

Certification. Attention is drawn to the certification facilities described on the inside back cover of this standard.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies essential requirements, test procedures and other information relating to non-oriented and oriented nickel-iron laminations intended for cores for transformer and inductor applications. The surface of laminations is normally oxide coated, but an additional surface coating (e.g. paint or lacquer) may be required by the customer (see 4.3).

2 References

The titles of the publications referred to in this standard are listed on page 26.

3 Definitions

For the purposes of this British Standard the following definitions apply, in addition to those included in BS 4727-1:Group 07.

3.1

effective permeability

a parameter of a magnetic circuit that equals the permeability of a hypothetical magnetic circuit of homogeneous construction having the same shape, dimensions and total reluctance. It is defined under stated conditions by the equation

$$\mu_e = \frac{L C_1}{\mu_0 N^2}$$

where L (H) is the equivalent series inductance of a coil of N turns associated with a core having a core factor C_1 (m^{-1}) and $\mu_0 = 4\pi \cdot 10^{-7} \text{ H.m}^{-1}$

3.2

core factor C_1

a factor related to the geometry of a magnetic circuit, calculated by the method given in Appendix A, defined by the equation

$$C_1 = \Sigma \frac{\ell}{A}$$

where $\frac{\ell}{A}$ is the ratio of magnetic path length (ℓ) to the corresponding cross-sectional area of the core (A)

3.3

core factor C_2

a factor related to the geometry of a magnetic circuit, calculated by the method given in Appendix A, defined by the equation

$$C_2 = \Sigma \frac{\ell}{A^2}$$

where $\frac{\ell}{A^2}$ is the ratio of magnetic path length (ℓ) to the square of the corresponding cross-sectional area of the core (A)

3.4

effective length ℓ_e

a derived magnetic path length related to the geometry of a magnetic circuit, calculated by the method given in Appendix A, defined by the equation

$$\ell_e = C_1^2 / C_1$$

3.5

effective area A_e

a derived magnetic path related to the geometry of a magnetic circuit, calculated by the method given in Appendix A, defined by the equation

$$A_e = C_1 / C_2$$

3.6

space factor

the ratio of iron area to total stack area in a cross section perpendicular to the surface of the laminations

3.7

square stack

the smallest number of laminations the height of which is, under a specified pressure, not less than the maximum width of the centre limb

3.8

equivalent parallel resistance coefficient

the ratio of that equivalent parallel resistance which will dissipate the same total power as the inductor (under stated conditions of measurement) to the square of the number of turns

3.9

remanence ratio

the ratio of remanence (see 2026 of BS 4727-1: Group 07) to flux density at saturation when measured from a specified peak magnetizing force

3.10

peak flux density

the peak value of periodic effective flux density in a core assembly given by the equation

$$B_e = \frac{E_{av} \times 10^6}{4 f A_e N}$$

where

B_e is the peak value of effective flux density (in T)

E_{av} is the value of the e.m.f. averaged over one half a cycle (in V)

f is the a.c. frequency (in Hz)

N is the number of turns of the test coil

A_e is the effective cross-sectional area of the magnetic bath (in mm²)

4 Physical and mechanical characteristics

4.1 Material. The laminations shall be made from material that falls into one of the classes described in Table 1.

Table 1 — Material classification

Class	Approximate composition range	Specific gravity
A	75 % to 80 % nickel plus additions, the bulk of which is iron	8.8
B1 and B2 ^a	45 % to 50 % nickel plus additions, the bulk of which is iron	8.3
C	34 % to 38 % nickel plus additions, the bulk of which is iron	8.1
D ^b	Grain oriented 45 % to 50 % nickel, the balance being iron	8.3
^a B2 material has a substantially higher permeability than B1. ^b D material is normally used only in special shapes (e.g. the ED range of laminations) to take advantage of its square hysteresis loop characteristics.		

4.2 Dimensions. The laminations shall have physical dimensions in accordance with Table 2 to Table 8 (as appropriate). In each case, the profile shall be symmetrical about datum width a . These are based on IEC Recommendations for the dimensions of laminations and are arranged as follows.

Table 2: EI range

Table 3: EE range

Table 4: F range

Table 5: E range

Table 6: ED range

Table 7: EE(L) range

Table 8: F(L) range

NOTE 1 The method of dimensional tolerancing is in accordance with BS 4500. Tolerance codes H12 and h12 apply to dimensions up to 10 mm; H11 and h11 to dimensions between 10 mm and 80 mm; H10 and h10 to dimensions greater than 80 mm.

NOTE 2 Any holes and/or notches in laminations (if required by the customer) may alter the magnetic characteristics (see clause 5).

Table 2 — Dimensions of EI range laminations

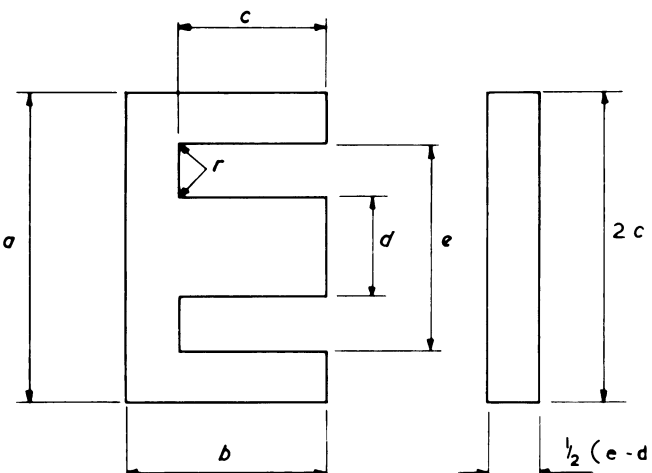
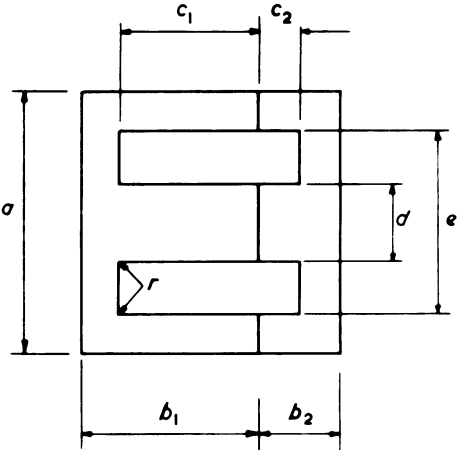
												
All dimensions are in millimetres.												
Designation	<i>a</i>		<i>b</i>		<i>c</i>		<i>d</i>		<i>e</i>		<i>r</i>	Sym. tol.
	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	width
EI 10	30.13	30.0	20.13	20.0	15.11	15.0	10.0	9.85	20.13	20.0	0.02	0.055
EI 12.8	38.56	38.4	25.73	25.6	19.33	19.2	12.8	12.69	25.73	25.6	0.025	0.055
EI 14 ^a	42.16	42.0	28.13	28.0	21.13	21.0	14.0	13.89	28.13	28.0	0.025	0.055
EI 16 ^a	48.16	48.0	32.16	32.0	24.13	24.0	16.0	15.89	32.16	32.0	0.025	0.06
EI 18 ^a	54.19	54.0	36.16	36.0	27.13	27.0	18.0	17.89	36.16	36.0	0.025	0.06
EI 20 ^a	60.19	60.0	40.16	40.0	30.16	30.0	20.0	19.87	40.16	40.0	0.032	0.065
EI 25 ^a	75.19	75.0	50.19	50.0	37.66	37.5	25.0	24.87	50.19	50.0	0.032	0.065
EI 32	96.14	96.0	64.19	64.0	48.16	48.0	32.0	31.84	64.19	64.0	0.04	0.08
^a Indicates preferred type.												

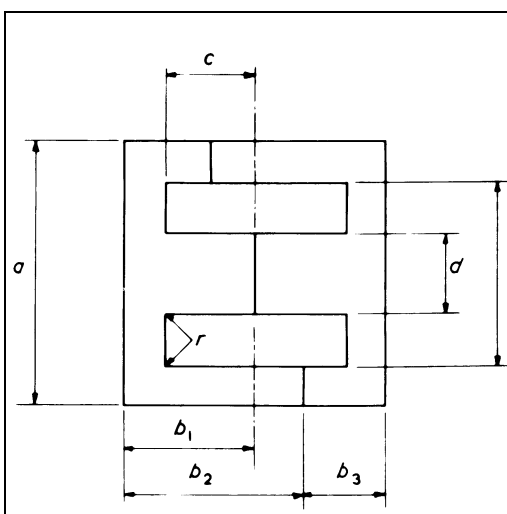
Table 3 — Dimensions of EE range laminations



All dimensions are in millimetres.

Designation	a		b ₁		b ₂		c ₁		c ₂		d		e		r	Sym. tol.
	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	width
EE 2.4	8.15	8.0	5.42	5.3	2.8	2.7	4.22	4.1	1.6	1.5	2.4	2.3	5.72	5.6	0.01	0.05
EE 3.0	10.11	10.0	6.85	6.7	3.42	3.3	5.32	5.2	1.9	1.8	3.0	2.9	7.15	7.0	0.01	0.05
EE 3.8	12.71	12.6	8.55	8.4	4.32	4.2	6.65	6.5	2.4	2.3	3.8	3.68	8.95	8.8	0.015	0.055
EE 4.8	16.11	16.0	10.81	10.7	5.42	5.3	8.45	8.3	3.0	2.9	4.8	4.68	11.31	11.2	0.015	0.055
EE 6.0	20.13	20.0	13.41	13.3	6.85	6.7	10.41	10.3	3.82	3.7	6.0	5.88	14.11	14.0	0.015	0.06
EE 7.6	25.13	25.0	16.81	16.7	8.45	8.3	13.01	12.9	4.62	4.5	7.6	7.45	17.51	17.4	0.02	0.06
EE 9.6	32.16	32.0	21.43	21.3	10.81	10.7	16.61	16.5	6.02	5.9	9.6	9.45	22.53	22.4	0.02	0.065
EE 12	40.16	40.0	26.83	26.7	13.41	13.3	20.83	20.7	7.45	7.3	12.0	11.89	28.13	28.0	0.025	0.065
EE 15	50.19	50.0	33.46	33.3	16.81	16.7	25.95	25.8	9.35	9.2	15.0	14.89	35.16	35.0	0.025	0.07
EE 19	64.19	64.0	42.86	42.7	21.43	21.3	33.36	33.2	11.91	11.8	19.0	18.87	45.16	45.0	0.032	0.07
EE 24	80.14	80.0	53.49	53.3	26.83	26.7	41.46	41.3	14.81	14.7	24.0	23.87	56.19	56.0	0.032	0.075
EE 30	100.14	100.0	66.89	66.7	33.46	33.3	51.89	51.7	18.43	18.3	30.0	29.87	70.19	70.0	0.032	0.075
EE 38	126.16	126.0	84.14	84.0	42.16	42.0	65.19	65.0	23.13	23.0	38.0	37.84	88.14	88.0	0.04	0.08

Table 4 — Dimensions of F range laminations



The diagram shows a cross-section of an F range lamination. It consists of a central core with two outer layers. The total height is labeled 'a'. The width of the central core is labeled 'c'. The width of the outer layers is labeled 'b1', 'b2', and 'b3'. The distance between the inner surfaces of the outer layers is labeled 'd'. The distance from the top surface of the outer layer to the top surface of the central core is labeled 'e'. The radius of the central core is labeled 'r'.

All dimensions are in millimetres.

Designation	<i>a</i>		<i>b</i> ₁		<i>b</i> ₂		<i>b</i> ₃		<i>c</i>		<i>d</i>		<i>e</i>		<i>r</i>	Sym. tol.
	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	width
F 2.4	8.15	8.0	4.12	4.0	5.3	5.18	2.7	2.6	2.9	2.8	2.4	2.3	5.72	5.6	0.01	0.05
F 3.0	10.11	10.0	5.12	5.0	6.7	6.55	3.3	3.18	3.6	3.5	3.0	2.9	7.15	7.0	0.01	0.05
F 3.8	12.71	12.6	6.45	6.3	8.4	8.25	4.2	4.08	4.52	4.4	3.8	3.68	8.95	8.8	0.015	0.055
F 4.8	16.11	16.0	8.15	8.0	10.7	10.59	5.3	5.18	5.7	5.6	4.8	4.68	11.31	11.2	0.015	0.055
F 6.0	20.13	20.0	10.11	10.0	13.3	13.19	6.7	6.55	7.15	7.0	6.0	5.88	14.11	14.0	0.015	0.06
F 7.6	25.13	25.0	12.61	12.5	16.7	16.59	8.3	8.15	8.85	8.7	7.6	7.45	17.51	17.4	0.02	0.06
F 9.6	32.16	32.0	16.11	16.0	21.3	21.17	10.7	10.59	11.31	11.2	9.6	9.45	22.53	22.4	0.02	0.065
F 12	40.16	40.0	20.13	20.0	26.7	26.57	13.3	13.19	14.11	14.0	12.0	11.89	28.13	28.0	0.025	0.065
F 15	50.19	50.0	25.13	25.0	33.3	33.14	16.7	16.59	17.61	17.5	15.0	14.89	35.16	35.0	0.025	0.07
F 19	64.19	64.0	32.16	32.0	42.7	42.54	21.3	21.17	22.63	22.5	19.0	18.87	45.16	45.0	0.032	0.07
F 24	80.14	80.0	40.16	40.0	53.3	53.11	26.7	26.57	28.13	28.0	24.0	23.87	55.19	56.0	0.032	0.075
F 30	100.14	100.0	50.19	50.0	66.7	66.51	33.3	33.14	35.16	35.0	30.0	29.87	70.19	70.0	0.032	0.075
F 38	126.16	126.0	63.19	63.0	84.0	83.86	42.0	41.84	44.16	44.0	38.0	37.84	88.14	88.0	0.04	0.08