

Laminations for transformers and inductors for use in telecommunication and electronic equipment —

**Part 1: Specification for dimensions,
mechanical characteristics and
electrical testing**

ICS 29.100.10; 29.180

Committees responsible for this British Standard

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- Electronic Components Industry Federation
- Electronic Engineering Association
- Ministry of Defence
- National Supervising Inspectorate
- Telecommunication Engineering and Manufacturing Association (TEMA)

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National foreword

This Part of this British Standard is published under the direction of the Electronic Components Standards Committee. It is identical with IEC 740:1982 “Laminations for transformers and inductors for use in telecommunication and electronic equipment” including Amendment 1, published by the International Electrotechnical Commission (IEC).

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

Wherever page numbers are quoted, they are IEC page numbers.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

Additional information.

Table II. Lamination thickness. Preferred and non-preferred lamination thicknesses (denoted by the symbols X and ⊗ respectively) are covered by this standard but the preferred values may be more readily available.

Table IX. Summary of preferred ranges. Not all sizes and shapes are necessarily available in all materials. Note should be taken of the country of origin listed in the tables of any particular range of interest.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, 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.

Section 1. General

1 Scope

This standard specifies the preferred sizes, and their associated tolerances, of laminations of various shapes, made from magnetic sheets or alloys of specified composition and thicknesses, their marking and packing, and also simple test methods for determining the electrical properties of cores made from such laminations.

The principal application for laminations complying with this specification is for transformers and inductors used in telecommunications and electronic equipment employing similar techniques.

2 Terms and definitions

2.1 General terms

For the definitions of the general terms used in this standard, reference should be made to IEC Publication 50: International Electrotechnical Vocabulary (I.E.V.) and in particular to Publication 50(901): International Electrotechnical Vocabulary, Chapter 901: Magnetism, and Publication 50(901B): Second supplement to Publication 50(901) (1973).

NOTE In this standard "oriented" is used a convenient abbreviation for "grain-oriented" (I.E.V. 901-01-39). Similarly, "non-oriented" implies "not grain-oriented".

For the purpose of this standard, the following definitions apply:

2.2

lamination

a lamination as produced from a magnetic steel or alloy sheet, usually consisting of one piece or two pieces together, forming one complete layer of a laminated core

2.3

stacking factor a

the ratio of the metal cross-section to the total stack or built-up cross-section (I.E.V. 901-04-36)

NOTE The terms "lamination factor" or "space factor" are sometimes used instead of "stacking factor".

Section 2. Mechanical characteristics

3 Materials and thicknesses

3.1 Materials

Laminations shall be made from one of the materials specified in Table I.

Table I — Magnetic steel and alloys used for laminations

Material (see IEC Publication 404-1 ^a)	Designation	Approximate composition in addition to iron
Low carbon mild steel	B	—
Silicon steel, non-oriented	C21	0.5 % to 4.5 % silicon
Silicon steel, oriented	C22	3 % silicon
Nickel-iron alloys	E1	72 % to 83 % nickel
	E3	45 % to 50 % nickel (both oriented and non-oriented)
	E4	35 % to 40 % nickel
Iron-cobalt alloys	F1	47 % to 50 % cobalt (isotropic)

^a Magnetic Materials, Part 1: Classification.

3.2 Nominal thickness

Lamination thickness shall be selected from one of the values specified in Table II, according to the material in use.

Table II — Lamination thickness^a

Material designation	Thickness in millimetres (see Note 1)								
	0.65	0.50	0.35	0.30	0.27	0.20	0.15	0.10	0.05
B, C21	⊗	X	X					⊗	
C22 (see Note 2)			X	X	X		X	X	⊗
E1, E3, E4 & F1			X	⊗		X	⊗	X	⊗
E3 oriented								X	⊗
NOTE 1 X indicates a preferred value.									
NOTE 2 Any thickness within the range 0.27 mm to 0.35 mm is a preferred value; this arises because several grades of material are produced in different thicknesses.									
^a See national foreword for additional information.									

3.3 Nominal stacking factors

Nominal stacking factors, determined for interleaved stacks of laminations assembled one by one and subjected to a uniform pressure of 15 kN/m² perpendicular to the plane of one lamination, shall be not less than the values specified in Table III, according to the material in use and its nominal thickness.

Table III — Material thicknesses and stacking factors

Material thickness (mm)	Nominal stacking factors		
	Low carbon mild steel and non-oriented silicon steel	Oriented silicon steel	Nickel-iron and cobalt-iron alloys
0.65	0.95	—	—
0.50	0.95	—	—
0.35	0.94	0.95	0.94
0.30	—	0.94	0.92
0.27	—	0.93	—
0.20	—	—	0.90
0.15	—	0.92	0.87
0.10	0.90	0.90	0.85
0.05	—	0.88	0.80

4 General appearance and conditions

4.1 Laminations shall be clean, free from rust and oil or cutting fluids. They shall be flat and free from burrs and distortion (to enable the requirements of Sub-clause 4.3 to be met).

4.2 Heat treated laminations shall be free from contaminating deposits.

4.3 Insulation shall be complete and uniform.

5 Dimensions and tolerances

5.1 The dimensions and tolerances of the preferred ranges of laminations are specified in Section Four. The tolerance on the lamination thickness equals that for the sheets.

Assembly fixing holes, when necessary, shall be placed at the intersecting points of the centre lines of the outer limbs.

5.2 The tolerances shall be in accordance with the requirements of ISO Recommendation R 286. The values corresponding to the reference designations at the head of each column of dimensions in the tables of Section 4 are given in Table IV.

5.3 The symmetry tolerances of dimensions a and e of the tables of Section 4 with respect to the centre line of the centre limb shall not exceed half the tolerance specified for the width of the centre limb (dimension d).

NOTE See also ISO Recommendation R 1101.

5.4 When sizes of laminations are used which are larger than specified in the tables of Section 4, the tolerances indicated in the headings of the columns shall still apply. Such laminations should be of the same shape as those in the tables and the ratios indicated in the tables should be maintained.

Table IV — Tolerance according to ISO Recommendation R 286

Size range		Tolerance code letters									
		IT10		IT11		IT12		IT13		IT14	
		μm	0.001"	μm	0.001"	μm	0.001"	μm	0.001"	μm	0.001"
1–3	0.04–0.12	40	1.6	60	2.5	100	4	140	5.5	250	10
3–6	0.12–0.24	48	1.8	75	3	120	5	180	7	300	12
6–10	0.24–0.40	58	2.2	90	3.5	150	6	220	8	360	14
10–18	0.40–0.71	70	2.8	110	4	180	7	270	11	430	16
18–30	0.71–1.19	84	3.5	130	5	210	8	330	13	520	20
30–50	1.19–1.97	100	4	160	6	250	10	390	15	620	24
50–80	1.97–3.15	120	4.5	190	7	300	12	460	18	740	28
80–120	3.15–4.73	140	5	220	8	350	14	540	21	870	36
120–180	4.73–7.09	160	6	250	10	400	16	630	25	1 000	40
180–250	7.09–9.85	185	7	290	12	460	18	720	28	1 150	44
250–315	9.85–12.41	210	8	320	12	520	20	810	32	1 300	50
315–400	12.41–15.75	230	9	360	14	570	22	890	35	1 400	56
400–500	15.75–19.7	250	10	400	16	630	25	970	38	1 550	60

Explanation. The tolerance code indicates the value of the tolerance in relation to the nominal dimension. For example, in Table X, YEI 1–10, the tolerance on b ($20 \text{ mm} \pm \frac{1}{2} \text{ IT12}$) is $\pm \frac{1}{2} \times 210 \mu\text{m} = \pm 0.105 \text{ mm}$; for e ($20 \text{ mm} \pm \frac{1}{2} \text{ IT14}$) it is $\pm \frac{1}{2} \times 520 \mu\text{m} = \pm 0.26 \text{ mm}$. In Table XI, YEx 2–2, the tolerance on d ($2.4 \text{ mm} + 0 - \text{IT11}$) is $+ 0 - 0.06 \text{ mm}$.

6 Designation of laminations

6.1 All designations of laminations consist of a combination of a letter symbol identifying the shape and a number representative of the size of the lamination.

6.2 The IEC designation consists of:

- the letter Y differentiating the IEC designation from all existing national designations;
- one or more letters identifying the shape;
- a serial number which distinguishes different ranges having the same letter designations;
- a dash followed by the approximate width d of the (centre) limb in millimetres.

Typical examples are:

YEI 1–40 (see Table X in Section 4)

YEE 3–20 (see Table XIII in Section 4)

YM 1–23 (see Table XVI in Section 4)

The original national designation is also given in the tables of Section 4.

7 Packaging and marking

7.1 The laminations shall be packed for transit in such a manner that no deterioration will occur.

7.2 Unless otherwise specified, both parts of two-part laminations shall be packed together.

7.3 All packages or boxes shall be marked with the following information:

- a) the lamination designation and thickness (for shape YM also the air-gap length);
- b) the quantity by mass or by approximate count;
- c) the material in accordance with Table I;
- d) the manufacturer's lot identification or date of manufacture.

Example of marking:

Lamination: YEI 1-40, thickness 0.35 mm.

Quantity: 100 kg.

Material: silicon steel, oriented.

Date of manufacture: 1/82.

Section 3. Electrical tests**8 General**

Electrical tests for stacked laminations shall be carried out for the appropriate materials specified in Table I according to the test parameters specified in Table V, Table VI, Table VII and Table VIII.

The following tests are intended as guidance to the simple testing of regularly used parameters.

9 Effective parameters

9.1 The core constants¹⁾ according to IEC Publication 205: Calculation of the Effective Parameters of Magnetic Piece Parts, are calculated in general as follows:

$$C_1 = \sum \frac{l}{A} \quad C_2 = \sum \frac{l}{A^2}$$

In the case of laminations, these constants are defined by:

$$C_1 = \frac{l_{Fe}}{A_{Fe}} \quad C_2 = \frac{l_{Fe}}{A_{Fe}^2}$$

where:

l_{Fe} = magnetic path length calculated as in Sub-clause 9.2.1

A_{Fe} = core area taking into account the stacking factor a (see Sub-clause 9.2.2)

Further, the core volume $V_{Fe} = l_{Fe} \times A_{Fe}$ and the core mass $m_{Fe} = V_{Fe} \times \rho$ where ρ = density of the magnetic material.

9.2 The effective parameters of laminated cores with square cross-sections and a stacking factor of 0.95 are given in the associated tables of Section 4 for the preferred laminations.

9.2.1 The magnetic path length l_{Fe} is calculated as the arithmetic mean of the longest and the shortest field path length of the core neglecting radii. For details on the calculation for each core, see Section 4.

9.2.2 The right section core area A_{Fe} is calculated as the product of centre limb width, stacking height and stacking factor: $A_{Fe} = d \times h \times a$. For the associated tables in Section 4, $h = d$ and $a = 0.95$ so that $A_{Fe} = 0.95 d^2$.

For other stacking heights and stacking factors (see Table III of Section 1), the values in the associated tables should be multiplied by:

$$\text{for } A_{Fe}: \frac{h}{d} \times \frac{a}{0.95}$$

$$\text{for } C_1: \frac{d}{h} \times \frac{0.95}{a}$$

Alternatively, for a given core stack, the core area may be determined as follows:

$$\text{for YEI, YEx, YUI and YM: } A_{Fe} = \frac{m_{Fe}}{l_{Fe} \cdot \rho}$$

$$\text{for YED: } A_{Fe} = \frac{0.9 m_{Fe}}{l_{Fe} \cdot \rho}$$

¹⁾ IEC Publication 50(901B) uses the equivalent term “core factor”.