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Calculation of the effective parameters of magnetic piece parts

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Calculation of the effective parameters of magnetic piece parts

FOREWORD

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IEC 60205 has been prepared by IEC technical committee 51: Magnetic components, ferrite and magnetic powder materials. It is an International Standard.

This fifth edition cancels and replaces the fourth edition published in 2016. This edition constitutes a technical revision.

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

a) addition, in 5.2, of the drawing and the formulae of pair of URS-cores of rectangular-circular section;
b) using, in 5.9, 5.10, 5.11 and 5.13, the conventional calculation formula that includes "B_1-D" is limited for the x-x cores (x is EL, ER, PQ or E) and addition new formulae for x-PLT cores that replaces "B_1-D" with "(B_1-D+B_2)/2";

c) addition, in 5.9, 5.10, 5.11 and 5.13, of formulae of l_1 and l_3 for x-PLT cores (x is EL, ER, PQ or E) which is different from the l_1 and l_3 of x-x cores;

d) addition of formula A_{min} in each subclause from 5.2.1 to 5.14.

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

Draft	Report on voting
51/1592/FDIS	51/1607/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

– reconfirmed,
– withdrawn, or
– revised.

1 Scope

This document specifies uniform rules for the calculation of the effective parameters of closed circuits of ferromagnetic material.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 Basic rules applicable to this standard

4.1 All results shall be expressed in units based on millimetres. It is recommended that the intermediate calculation values used to derive l_e, A_e, V_e, C_1 and C_2 have at least 10 decimal places. Finally calculated l_e, A_e, V_e and A_{min} shall be rounded to three significant figures, and C_1 and C_2 shall be rounded to five significant figures. All angles are in radians.

NOTE The purpose of specifying this degree of accuracy is only to ensure that parameters calculated at different establishments are identical and it is not intended to imply that the parameters are capable of being determined to this accuracy.

4.2 A_{min} is the nominal value of the smallest cross-section. A_g is the geometrical cross-section of a ring core with rectangular shape. All the dimensions used to calculate A_{min} shall be the mean values between the tolerance limits quoted on the appropriate piece part drawing. All results shall be expressed in units based on millimetres and shall be accurate to three significant figures.

NOTE A_g is used for the measurement of the saturation flux density B_s on ring cores with rectangular cross-section.

4.3 Calculations are only applicable to the component parts of a closed magnetic circuit.

4.4 All dimensions used for the purpose of calculations shall be the mean value within the tolerance limits quoted on the appropriate piece part drawing.

4.5 All irregularities in the outline of the core, such as small cut-outs, notches, chamfers, etc. shall be ignored, unless otherwise described in this document.

4.6 When the calculation involves the sharp corner of a piece part, then the mean length of flux path for that corner shall be taken as the mean circular path joining the centres of area of the two adjacent uniform sections, and the cross-sectional area associated with that length shall be taken as the average area of the two adjacent uniform sections.

The effective parameters l_e, A_e and V_e can be calculated as:

$$l_e = C_1^2 / C_2 \qquad A_e = C_1 / C_2 \qquad V_e = l_e A_e = C_1^3 / C_2^2$$

where

l_e is the effective magnetic length of the core (mm);

A_e is the effective cross-sectional area (mm^2);

V_e is the effective volume (mm^3);

C_1 is the core constant (mm^{-1});

C_2 is the core constant (mm^{-3}).

5 Formulae for the various types of cores

5.1 Ring cores

5.1.1 Ring cores in general

Drawings of ring cores are shown in Figure 1.

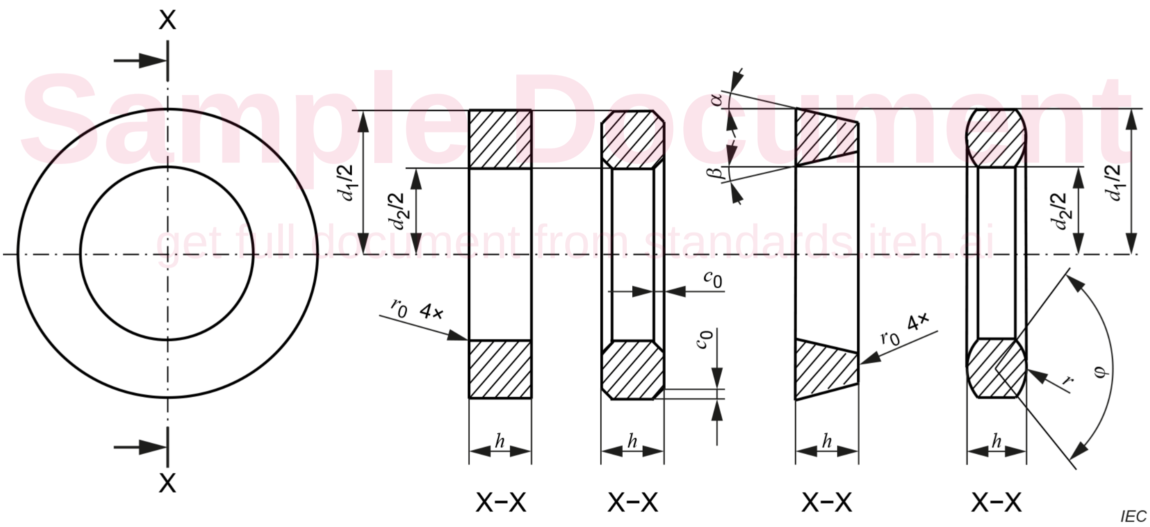

Figure 1 – Ring cores

$$C_1 = \frac{2\pi}{h_e \ln(d_1 / d_2)}$$

$$C_2 = \frac{4\pi(1/d_2 - 1/d_1)}{h_e^2 \ln^3(d_1 / d_2)}$$

5.1.2 For ring cores of rectangular cross-section with sharp corners

The formula is as follows:

$$h_e = h$$

The geometrical cross-section of a ring core with rectangular shape A_g is given as:

$$A_g = h\frac{d_1 - d_2}{2}$$

5.1.3 For ring cores of rectangular cross-section with an appreciable average rounding radius r_0

The formula is as follows:

$$h_e = h(1 - k_1) \quad k_1 = \frac{1{,}7168 r_0^2}{h(d_1 - d_2)}$$

5.1.4 For ring cores of rectangular cross-section with appreciable chamfer c_0

The formula is as follows:

$$h_e = h(1 - k_3) \quad k_3 = \frac{4c_0^2}{h(d_1 - d_2)}$$

The geometrical cross-section of a ring core with appreciable chamfer shape A_g is given as:

$$A_g = h\frac{d_1 - d_2}{2} - 2c_0^2$$

5.1.5 For ring cores of trapezoidal cross-section with sharp corners

The formula is as follows:

$$h_e = h(1 - k_2) \quad k_2 = \frac{h(\tan\alpha + \tan\beta)}{d_1 - d_2}$$

5.1.6 For ring cores of trapezoidal cross-section with an appreciable average rounding radius r_0

The formula is as follows:

$$h_e = h(1 - k_1 - k_2)$$

5.1.7 For ring cores of cross-section with circular arc frontal sides

The formula is as follows:

$$h_e = h - \frac{d_1 - d_2}{4\sin^2(\varphi/2)}\left(2\sin\frac{\varphi}{2} - \frac{\sin\varphi}{2} - \frac{\varphi}{2}\right)$$

$$\varphi = 2\arcsin\frac{d_1 - d_2}{4r}$$

When the winding is uniformly distributed over a ring core, it can be expected that, at all points inside the ring core, the flux lines will be parallel to its surface.

No leakage flux will therefore leave or enter the ring core. This justifies the use of a theoretically more correct derivation of the effective parameters, which does not make use of the assumption that the flux is uniformly distributed over the cross-section.

5.2 Pair of U-cores

5.2.1 Pair of U-cores of rectangular section

Drawings of a pair of U-cores of the rectangular section are shown in Figure 2.

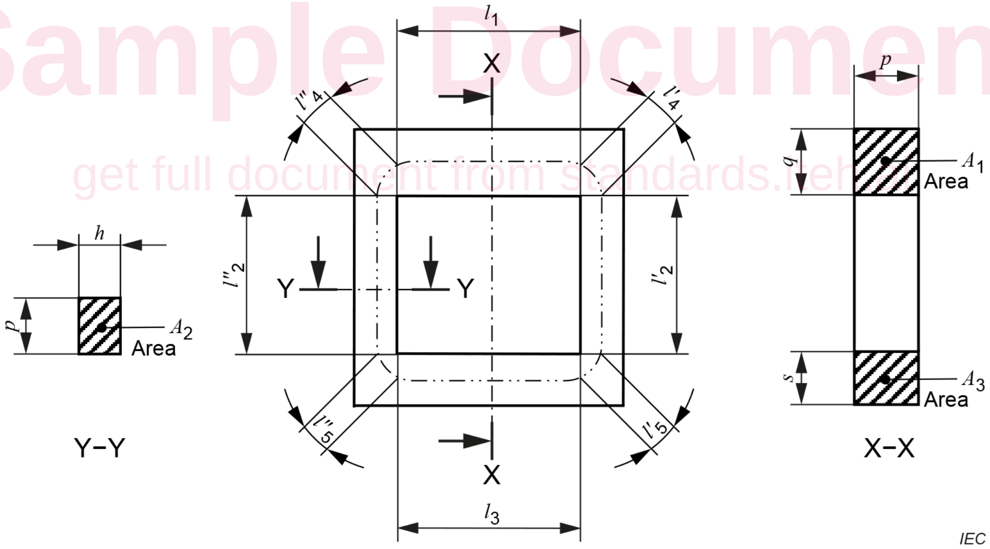

Figure 2 – Pair of U-cores of the rectangular section

$$A_1 = pq$$

$$A_2 = hp$$

$$A_3 = ps$$

Length of flux path associated with area A_2:

$$l_2 = l_2' + l_2''$$

Mean length of flux path at corners:

$$l_4 = l'_4 + l''_4 = \frac{\pi}{4}(q + h)$$

$$l_5 = l'_5 + l''_5 = \frac{\pi}{4}(s + h)$$

Mean areas associated with l_4 and l_5:

$$A_4 = \frac{A_1 + A_2}{2}$$

$$A_5 = \frac{A_2 + A_3}{2}$$

$$C_1 = \sum_{i=1}^{5} \frac{l_i}{A_i} \qquad C_2 = \sum_{i=1}^{5} \frac{l_i}{{A_i}^2}$$

5.2.2 Pair of UR-cores

Drawings of a pair of UR-cores with the rounded section are shown in Figure 3.

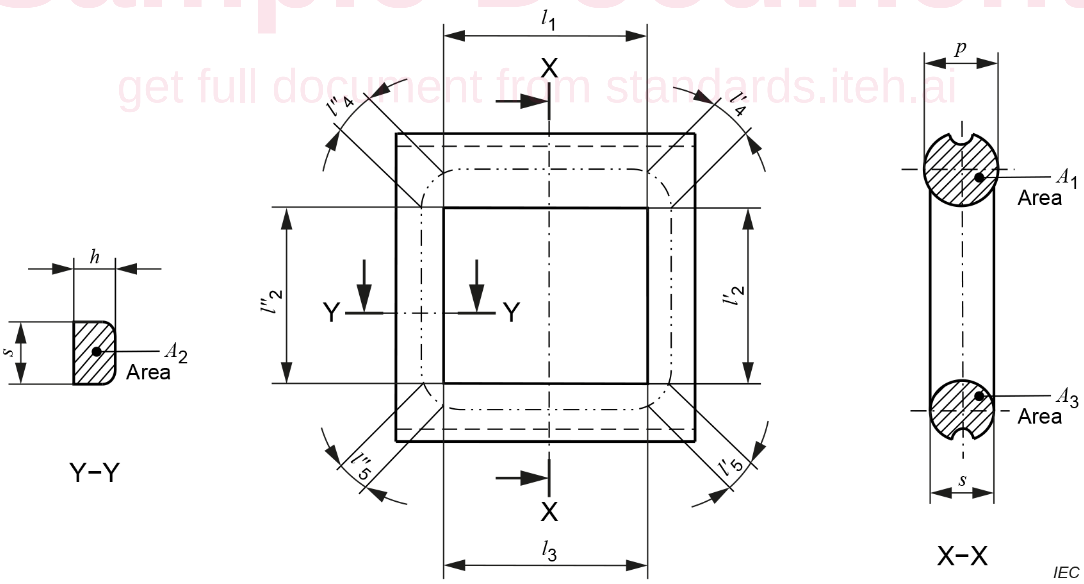

Figure 3 – Pair of UR-cores of rounded section

In calculating A_2, ignore any ridges introduced for the purpose of facilitating manufacture.

$$A_1 = \frac{\pi}{4} p^2$$

$$A_2 = hs$$

$$A_3 = \frac{\pi}{4} s^2$$

Length of flux path associated with area A_2:

$$l_2 = l_2' + l_2''$$

Mean length of flux path at corners:

$$l_4 = l_4' + l_4'' = \frac{\pi}{4}(p + h)$$

$$l_5 = l_5' + l_5'' = \frac{\pi}{4}(s + h)$$

Mean areas associated with l_4 and l_5:

$$A_4 = \frac{A_1 + A_2}{2}$$

$$A_5 = \frac{A_2 + A_3}{2}$$

$$C_1 = \sum_{i=1}^{5} \frac{l_i}{A_i} \quad C_2 = \sum_{i=1}^{5} \frac{l_i}{A_i^2}$$