IEC 60205

Edition 3.0 2006-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Calculation of the effective parameters of magnetic piece parts

Calcul des paramètres effectifs des pièces magnétiques

IEC 60205:2006

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CALCULATION OF THE EFFECTIVE PARAMETERS OF MAGNETIC PIECE PARTS

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60205 has been prepared by IEC technical committee 51: Magnetic components and ferrite materials.

This third edition cancels and replaces the second edition published in 2001, corrigendum 1 (2001). This edition constitutes a technical revision.

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

a) unit of angles through the text are described by using "radian";
b) new words are added in 2.1 "All angles are in radians";
c) replacement, Clause 3.9, of the equation $\frac{l_2}{A_2} = \frac{\ln d_2 g / d_3}{D\pi(h_1 - h_2)}$ by $\frac{l_2}{A_2} = \frac{\ln d_2 g / d_3}{D\pi(h_1 - h_2)/2}$;
d) new cores "EL, ER, PQ, EFD and E planar" are added in this edition.

This bilingual version, published in 2009-01, corresponds to the English version.

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

FDIS	Report on voting
51/848/FDIS	51/857/RVD

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

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

CALCULATION OF THE EFFECTIVE PARAMETERS OF MAGNETIC PIECE PARTS

1 Scope

This International Standard lays down uniform rules for the calculation of the effective parameters of closed circuits of ferromagnetic material.

2 Basic rules

The following basic rules are applicable to this standard.

2.1 All results shall be expressed in units based on the millimetre, shall be accurate to three significant figures, but to derive l_e , A_e , and V_e the values of C_1 and C_2 shall be calculated 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.

2.2 A_{min} is the nominal value of the smallest cross-section. All the dimensions used to calculate A_{min} shall be the mean values between the tolerance limits quoted on the appropriate piece part drawing.

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

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

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

2.6 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.

Calculation of effective parameters l_e , A_e and V_e.

The effective parameters can be defined 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);

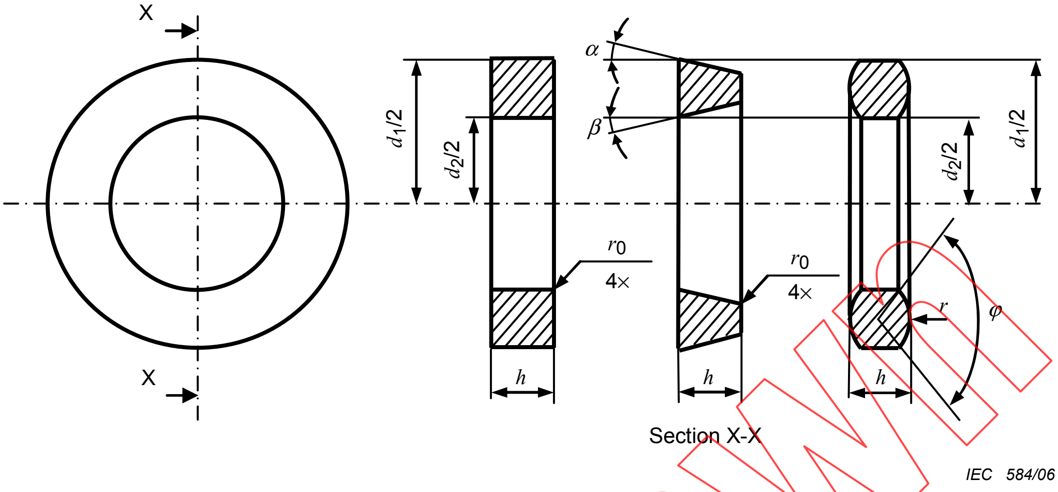
V_e is the effective volume (mm^3);

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

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

3 Formulae for the various types of cores

3.1 Ring cores



Section X-X

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

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

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

$$h_e = h$$

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

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

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

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

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

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

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

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

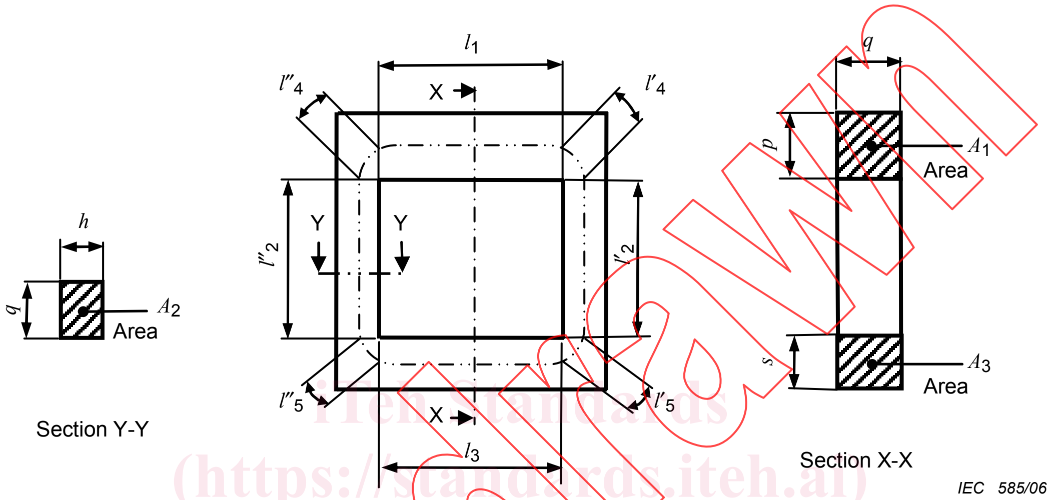
$$\varphi = 2\arcsin\frac{d_1 - d_2}{4r}.$$

NOTE When the winding is uniformly distributed over a ring core, it may 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.

3.2 Pair of U-cores of rectangular section

NOTE U + PLT (Plate)-cores use U core formulas.



Length of flux path associated with area A_2:

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

Mean length of flux paths 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:

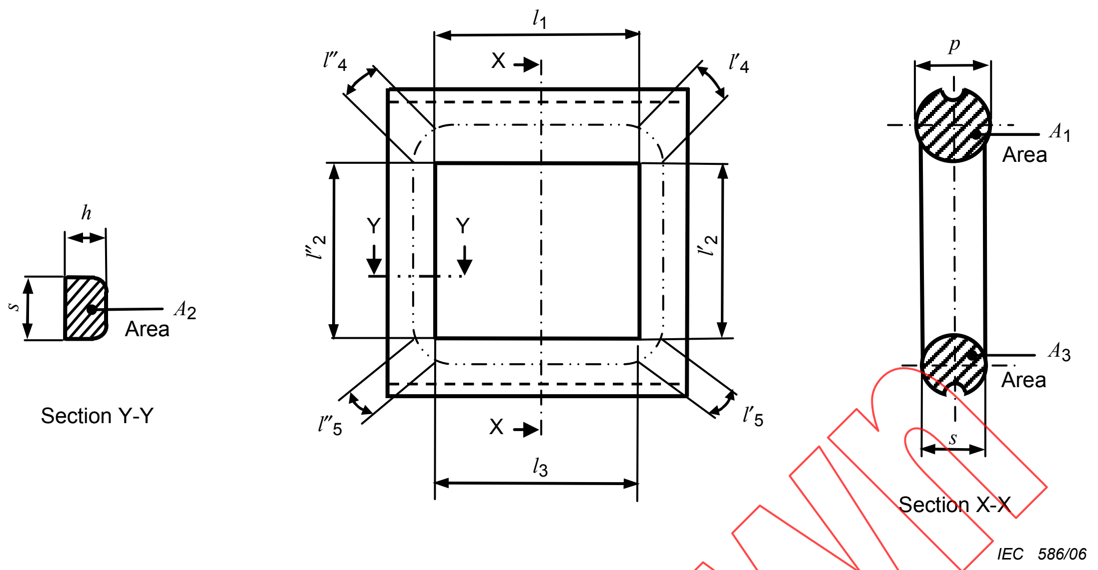
$$A_4 = \frac{A_1 + A_2}{2}$$

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

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

3.3 Pair of U-cores of rounded section

NOTE U + PLT (Plate)-cores use U core formulas.



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

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:

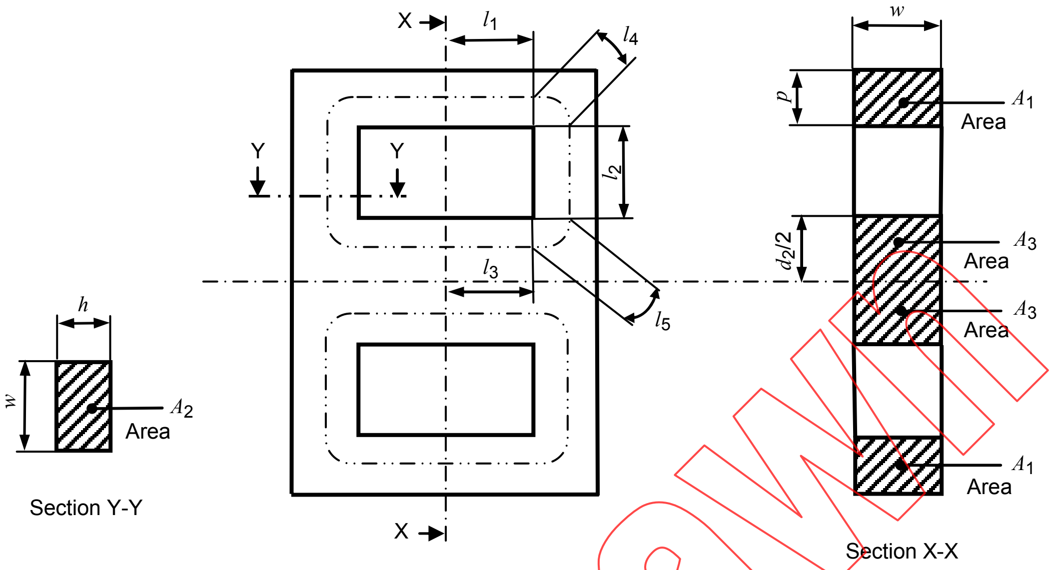
$$A_4 = \frac{A_1 + A_2}{2}$$

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

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

3.4 Pair of E-cores of rectangular section

NOTE E + I (Plate)-cores use E core formulas.



IEC 587/06

Area of half the centre limb: A_3

Mean length of flux paths at corners:

$$l_4 = \frac{\pi}{8}(p+h)$$

$$l_5 = \frac{\pi}{8}\left(\frac{d_2}{2}+h\right)$$

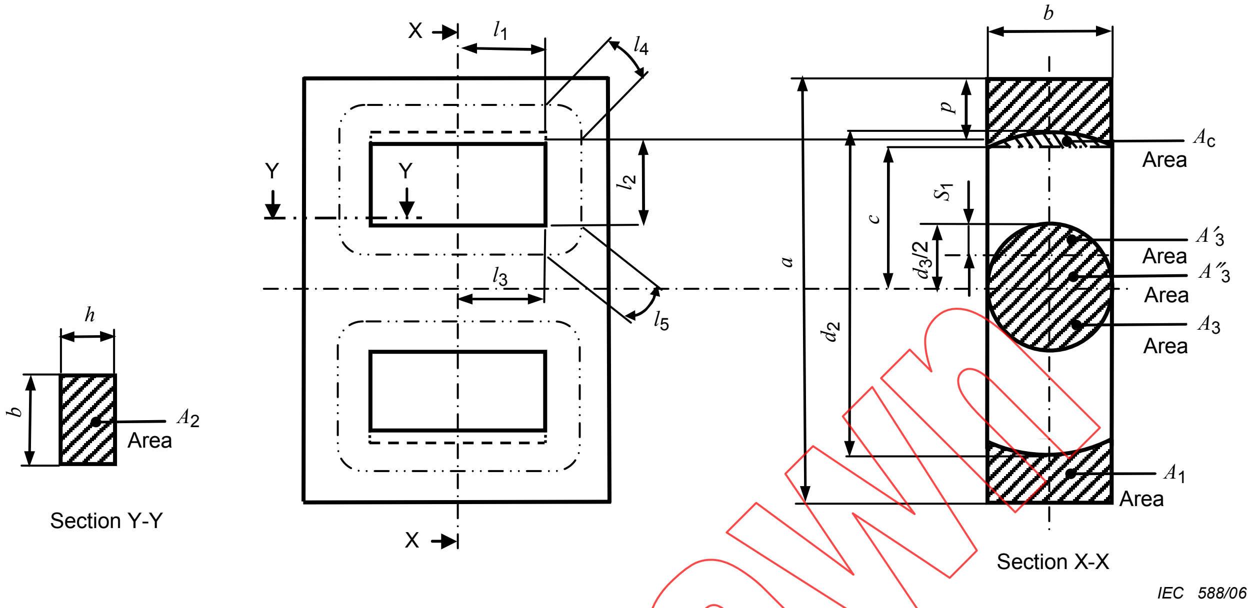
Mean areas associated with l_4 and l_5:

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

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

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

3.5 Pair of ETD/EER-cores



A_1 is equal to the rectangle $b\left(\frac{1}{2}a - c\right)$ less the cap or segment A_c.

$$A_C = \frac{1}{4} d_2^{\,2} \arcsin\left(\frac{b}{d_2}\right) - \frac{1}{4} b\sqrt{d_2^{\,2} - b^2}$$

$$A_1 = \frac{1}{2} ab - \frac{1}{4} b\sqrt{d_2^{\,2} - b^2} - \frac{1}{4} d_2^{\,2} \arcsin\left(\frac{b}{d_2}\right)$$

Mean length of flux path at back walls:

$$l_2 = \frac{1}{4}\left(d_2 + \sqrt{d_2^{\,2} - b^2}\right) - \frac{d_3}{2}$$

NOTE l_2 is taken from the mean value of $\frac{1}{2}(d_2 - d_3)$ and $(c - d_3/2)$.

Area of half the centre limb:

$$A_3 = A_3' + A_3''$$

The condition to obtain $A_3' = A_3''$ is

$$S_1 = 0{,}2980 d_3$$

Mean length of flux path at corners:

$$l_4 = \frac{\pi}{8}(p + h)$$

where $p = \frac{a}{2} - l_2 - \frac{d_3}{2}$

$$l_5 = \frac{\pi}{8}(2S_1 + h)$$

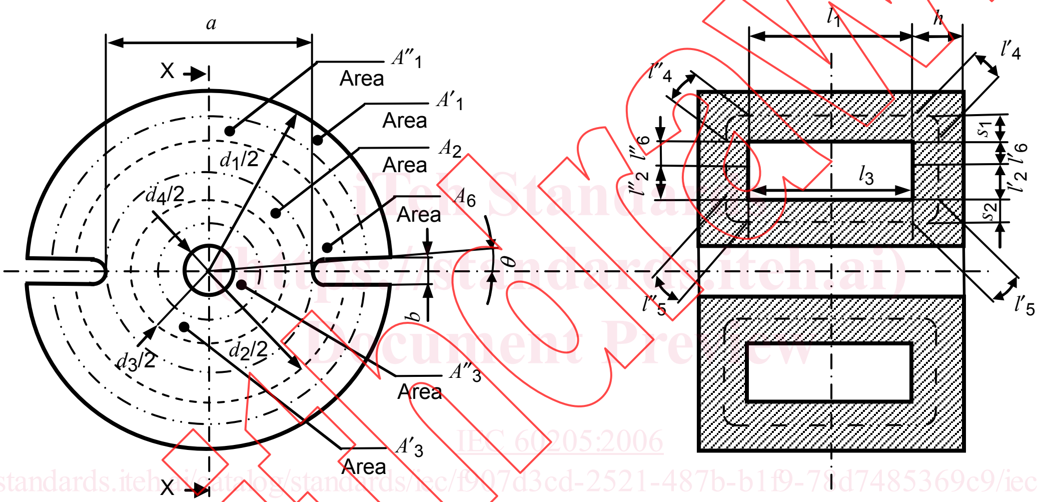
Mean areas associated with l_4 and l_5:

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

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

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

3.6 Pair of pot-cores



Section X-X

IEC 589/06

Area of outer ring:

$$A_1 = A_1' + A_1''$$

The condition to obtain $A_1' = A_1''$ is

$$S_1 = -\frac{d_2}{2} + \sqrt{\frac{1}{8}\left(d_1^{\,2} + d_2^{\,2}\right)}$$

Area of centre limb:

$$A_3 = A_3' + A_3''$$

The condition to obtain $A_3' = A_3''$ is

$$S_2 = \frac{d_3}{2} - \sqrt{\frac{1}{8}\left(d_3^{\,2} + d_4^{\,2}\right)}$$

Area of ring:

$$A_1 = \frac{1}{4}(\pi - n\theta)\left(d_1^{\,2} - d_2^{\,2}\right)$$

$$\theta = \arcsin\frac{2b}{d_1 + d_2}$$

where

b is the slot width;

n is the number of slots.

Core factors associated with l_2:

$$\frac{l_2}{A_2} = \frac{1}{\pi h}\ln\frac{a}{d_3}$$

$$\frac{l_2}{A_2^{\,2}} = \frac{a - d_3}{\pi^2 a d_3 h^2}$$

Area of centre limb:

$$A_3 = \frac{\pi}{4}\left(d_3^{\,2} - d_4^{\,2}\right)$$

Mean length of flux paths at corners:

$$l_4 = l_4' + l_4'' = \frac{\pi}{4}(2S_1 + h)$$

$$l_5 = l_5' + l_5'' = \frac{\pi}{4}(2S_2 + h)$$

Areas associated with l_4 and l_5:

$$A_4 = \frac{1}{8}(\pi - n\theta)\left(d_1^{\,2} - d_2^{\,2}\right) + \frac{\pi}{2}d_2 h$$

$$A_5 = \frac{\pi}{8}\left(d_3^{\,2} - d_4^{\,2} + 4d_3 h\right)$$

Core factors associated with l_6:

$$\frac{l_6}{A_6} = \frac{1}{(\pi - n\theta)h}\ln\frac{d_2}{a}$$

$$\frac{l_6}{A_6^{\,2}} = \frac{d_2 - a}{a d_2 (\pi - n\theta)^2 h^2}$$

$$C_1 = \sum_{i=1}^{6}\frac{l_i}{A_i} \qquad C_2 = \sum_{i=1}^{6}\frac{l_i}{A_i^{\,2}}$$