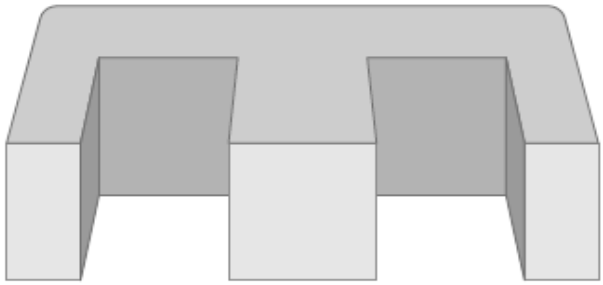
The International Magnetics Association



Standard Specifications for

Ferrite E, U, and I Cores

The International Magnetics Association

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FOREWORD

This standard on ferrite cores was developed by the engineering committee of the Soft Ferrite Division of the Magnetic Materials Producers Association. Several International Electrotechnical Commission documented recommendations have been included in this standard. The specific IEC publications that have been used in total or in part are:

IEC 647 Dimensions for Magnetic Oxide Cores for use in Power Supplies (EC Cores)

LEC 205 Calculation of effective parameters of magnetic piece parts

ISO Recommendations: R370 was used in the conversion of toleranced dimensions from inches into millimeters and vice versa.

This core standard is only an advisory document and its use or adaptation is entirely voluntary.

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Standard Specifications for FERRITE U, E AND I CORES

1.0 SCOPE

This standard defines rectangular cross-section E cores, EC cores and ETD cores, their dimensions and tolerances. It also defines acceptance limits for variation in form, surface condition and general appearance common to U, E and I cores.

2.0 DIMENSIONS AND TOLERANCES

2.1 The physical dimensions of the standard series of EC cores shall be in accordance with Table 1. For dimensional details see Figure 1

Table 1
DIMENSIONS OF EC CORES

SIZE	TOL	D_1		D_2		D_4				H_1		H_2		W		S		R	
		mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
EC	MIN.	34	1.33	28	1.09	22	0.87	9.2	0.36	17.2	0.675	12	0.47	9.2	0.36	2.5	0.1	—	—
	MAX.	35	1.39	29	1.15	23	0.92	9.8	0.39	17.5	0.687	13	0.5	9.8	0.39	3	0.12	0.5	0.20
EC 41	MIN.	40	1.56	33	1.28	26	1.04	11.3	0.45	19.4	0.762	14	0.53	11.3	0.45	3	0.12	—	—
	MAX.	42	1.64	35	1.36	28	1.09	11.9	0.47	19.7	0.774	14	0.56	11.9	0.47	3.5	0.14	0.7	0.028
EC 52	MIN.	51	2	43	1.68	32	1.26	13.1	0.51	24.1	0.947	16	0.61	13.1	0.51	3.5	0.14	—	—
	MAX.	54	2.11	45	1.78	34	1.34	13.8	0.54	24.4	0.959	16	0.64	13.8	0.54	4	0.16	0.8	0.031
• EC 70	MIN.	68	2.69	58	2.28	43	1.71	16	0.63	34.4	1.352	22	0.88	16	0.63	4.5	0.18	—	—
	MAX.	72	2.82	61	2.41	46	1.8	16.8	0.66	34.7	1.364	23	0.91	16.8	0.66	5	0.2	1.0	0.039

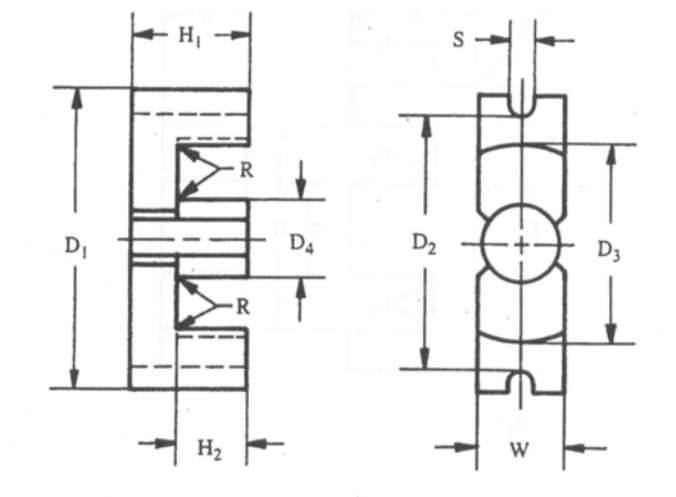


FIGURE 1 EC CORE

2.2 The physical dimensions of E cores with rectangular cross-section shall be in accordance with Table 2. For dimensional details see Figure 2.

Table 2
DIMENSIONS OF E-CORES WITH RECTANGULAR CROSS-SECTION

SIZE	TOL	D_1		D_2		D_3		H_1		H_2		w		R_1		R_2	
		mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in
E13/4	MIN.	12	0.48	8.9	0.35	3.4	0.13	6.3	0.25	4.5	0.177	3.4	0.13	—	—	—	—
	MAX.	13	0.52	9.5	0.37	3.7	0.15	6.5	0.26	4.8	0.189	3.7	0.15	1	0.039	0.3	0.01
E16/5	MIN.	16	0.61	11	0.45	4.4	0.17	7.9	0.31	5.7	0.224	4.3	0.17	—	—	—	—
	MAX	17	0.66	12	0.49	4.7	0.19	8.2	0.32	6.1	0.24	4.7	0.19	1	0.039	0.3	0.01
E20/6	MIN.	19	0.76	14	0.56	5.5	0.22	9.8	0.39	7	0.276	5.4	0.21	—	—	—	—
	MAX	21	0.82	15	0.58	5.9	0.23	10.2	0.4	7.4	0.291	5.9	0.23	1.5	0.059	0.4	0.02
E25/7	MIN.	24	0.96	18	0.69	7	0.28	12.3	0.48	8.7	0.343	6.9	0.27	—	—	—	—
	MAX	26	1.02	18	0.72	7.5	0.3	12.8	0.5	9.2	0.362	7.5	0.3	2	0.079	0.5	0.02
E3219	MIN.	31	1.23	23	0.89	8.9	0.35	15.8	0.62	11.2	0.441	8.8	0.35	—	—	—	—
	MAX.	33	1.3	24	0.93	9.5	0.37	16.4	0.65	11.8	0.465	9.5	0.37	2.5	0.098	0.6	0.02
E42/15	MIN.	41	1.63	30	1.16	12	0.46	20.8	0.82	14.8	0.583	15	0.58	—	—	—	—
	MAX.	43	1.69	31	1.21	12	0.48	21.2	0.83	15.5	0.61	15	0.6	2.5	.0.098	0.6	0.02
E42/20	MIN.	41	1.63	30	1.16	12	0.46	20.8	0.82	14.8	0.583	19	0.76	—	—	—	—
	MAX.	43	1.69	31	1.21	12	0.48	21.2	0.83	15.5	0.61	20	0.79	2.5	0.096	0.6	0.02
E55/21	MIN.	54	2.13	38	1.48	17	0.66	27.2	1.07	18.5	0.728	20	0.8	—	—	—	—
	MAX.	56	2.21	39	1.52	17	0.68	27.8	1.1	19.3	0.76	21	0.83	3	0.118	0.6	0.02
E55/25	MIN.	54	2.13	38	1.48	17	0.66	27.2	1.07	18.5	0.728	24	0.95	—	—	—	—
	MAX.	56	2.21	39	1.52	17	0.68	27.8	1.1	19.3	0.76	25	0.98	3	0.118	0.6	0.02
E65/27	MIN.	64	2.51	44	1.74	19	0.76	32.2	1.27	22.2	0.874	27	1.05	—	—	—	—
	MAX.	67	2.62	46	1.8	20	0.79	32.8	1.29	23	0.906	27	1.08	3	0.118	1	0.04

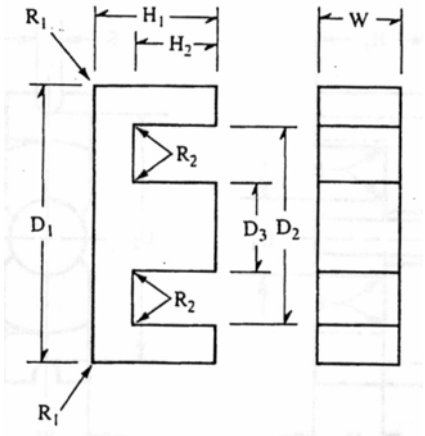


FIGURE 2 E CORE

The physical dimensions of the ETD cores shall be in accordance with Table 3. For dimensional details see Figure 3.

Table 3
DIMENSIONS OF ETD CORES

SIZE	TOL	D_1		D_3		D_3		H_1		H_2		W		R	
		mm	In	mm	In	mm	In	mm	In	mm	in	mm	in.	mm	In
ETD29	MIN.	29	1.15	22	0.87	9.2	0.36	15.6	0.61	10.7	0.421	9.2	0.36	—	—
	MAX	31	1.21	23	0.92	9.8	0.39	16	0.63	11.3	0.443	9.8	0.39	0.5	0.02
ETD34	MIN.	33	1.32	26	1.01	11	0.41	17.1	0.67	11.8	0.465	11	0.41	—	—
	MAX	35	1.38	27	1.06	11	0.44	17.5	0.69	12.4	0.488	11	0.44	0.5	0.02
ETD39	MIN.	38	1.5	29	1.15	12	0.48	19.6	0.77	14.2	0.559	12	0.48	—	—
	MAX	40	1.58	31	1.27	13	0.5	20	0.79	15	0.591	13	0.5	0.6	0.024
ETD44	MIN.	43	1.69	33	1.28	14	0.57	22.1	0.87	16.1	0.634	14	0.57	—	—
	MAX	45	1.77	34	1.34	15	0.6	22.5	0.89	16.9	0.665	15	0.6	0.7	0.031
ETD49	MIN.	48	1.87	36	1.42	16	0.63	24.5	0.96	17.7	0.697	16	0.63	—	—
	MAX	50	1.96	38	1.49	17	0.66	24.9	0.98	18.5	0.728	17	0.66	0.7	0.031

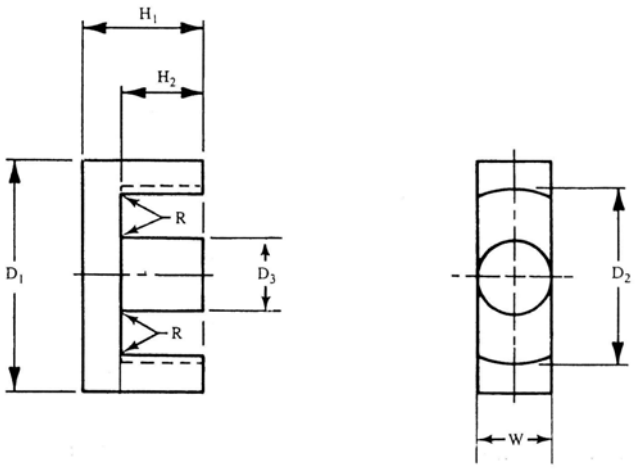


FIGURE 3 ETD CORE

3.0 DESIGN GUIDELINES FOR DIMENSIONAL TOLERANCES AND ALLOWABLE DISTORTIONS.

3.1 Tables 4, *5* and 6 list tolerances for U, E and I cores respectively. These are considered to be preferred minimums. In applications where wider tolerances are allowable, cost savings may be realized by specifying wider tolerances. Refer to Figures 4 and *5* for U cores, Figure 6 for E cores and Figure 7 for I cores~

3.2 The bolt slot nominal should be 0.015 inch larger than the maximum diameter of the bolt being used.

3.3 Table 7 illustrates the various distortions and their allowable *limits.* Refer to Figures *4,5,* 6 and 7 for dimensions. While U cores are shown, the conditions apply for E cores also. Warpage and twist considerations apply to U cores.

Table 4
DESIGN GUIDELINES FOR U CORES

DIMENSION	TOLERANCE	FIGURE
D_1 measured at back of core	± .010 inch or ±2% whichever is greater	4 & 5
D_2	± .010 inch or ±3% whichever is greater	4 & 5
D_3 measured at open end	± .010 inch or ±3% of D1 whichever is greater	4 & 5
D_4	Reference only	4
H_1	± .010 inch or ± 1% whichever is greater	4 & 5
H_2	± .010 inch or ± 3% whichever is greater	4 & 5
WI	± .015 inch or ± 2% whichever Is greater	4 & 5
S (See para. 3.2)	± .010 inch	4 & 5

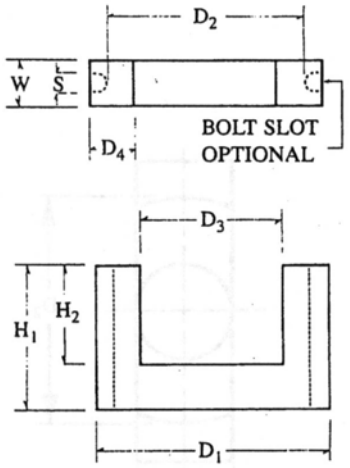


FIGURE 4 U CORE RECTANGULAR

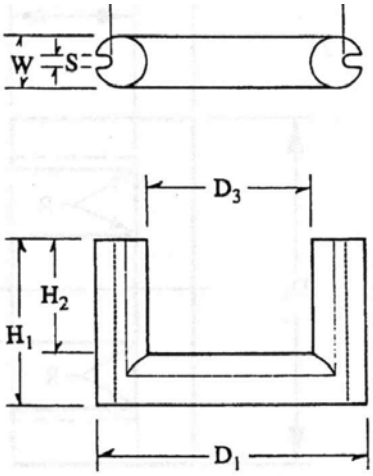


FIGURE 5 U CORE ROUND

DIMENSION	TOLERANCE	FIGURE
D_1	±3%	6
D_2	±3%	6
D_3	± .010 inch or ±2% whichever is greater	6
H_1	± .010 inch or ± 1% whichever is greater	6
H_2	± .010 inch or ± 3% whichever is greater	6
W	± .015 inch or ±3% whichever is greater	6

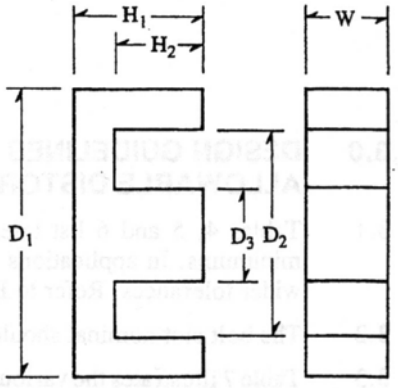


FIGURE 6 E CORE

Table 6
DESIGN GUIDELINES FOR I CORES

DIMENSION	TOLERANCE	FIGURE
D_1	Same as D_1 for U or E core as mated.	7
W	±.Ol5inchor±3%	7
H	.010 inch or ±1% whichever is greater	7

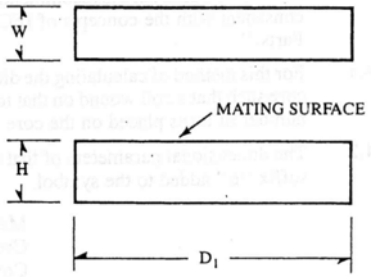
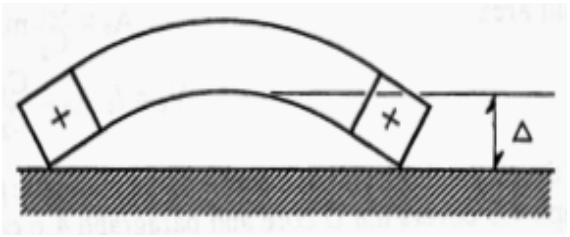
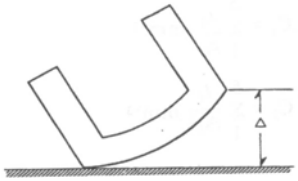
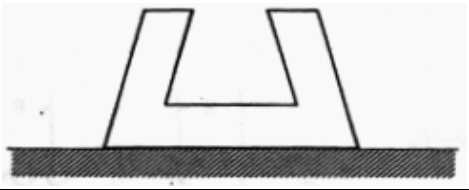
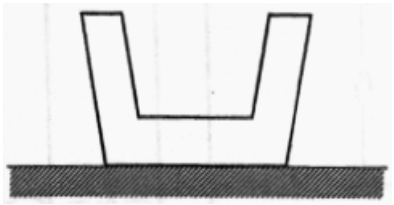
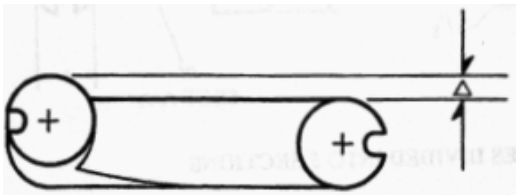


FIGURE 7 I CORE

Warpage TYPE 1		.015 inch or .010 inch per Inch of D_1, whichever is greater.
Warpage TYPE 2		.010 inch per inch of D
Toe-In		Dimensions in tables 4 & 5 cover allowable distortion.
Toe-Out		Dimensions In tables 4 & 5 cover allowable distortion.
Twist		.030 inch or .020 inch per inch of D_1 whichever is greater.

4.0 CALCULATION OF DIMENSIONAL PARAMETERS OF U, E, AND I CORES

The method used here is recommended for the calculation of the dimensional parameters of U, E and I cores and is consistent with the concepts of IEC Publication *205,* "Calculation of Effective Parameters of Magnetic Piece Parts.

4. 1 For this method of calculating the dimensional parameters of cores, the core set is substituted by an ideal toroidal core such that a coil wound on that toroid would give exactly the same electrical performance as a coil with some number of turns placed on the core set.

4.2 The dimensional parameters of that substitute toroid are called effective parameters. These are indicated by the suffix "e" added to the symbol.

Magnetic path length	Ie mm
Cross-sectional area	A_e mm^2
Core volume	V_e mm^3

4.3 For the purpose of the calculation of the dimensional parameters, the closed magnetic circuit of the core set is divided into five sections. The core constants for the total magnetic circuit of the core set are:

$$C_1 = \Sigma\, l_e/A_e \text{ mm-1 } \& \; C_2 = \Sigma\, l_e/a_e^2 \text{ mm-}^3$$

From these core constants the effective dimensional core parameters can be calculated.

Magnetic path length	$Ie = C_1^2/C_2$ mm
Cross-sectional area	$Ae = C_1/C_2$ mm^2
Core volume	$Ve = Ie\ Ae = C_1^3/C_2^2$ mm^3

4.4 For each of the five sections of the magnetic circuit of a core set, the magnetic path length and cross-sectional area

has to be determined: Paragraph *4.5* covers the U core and paragraph 4.6 covers the E core.

$$C_1 = \sum_{1}^{5} l_1/A_1 \text{ mm}^{-1}$$

$$C_2 = \sum_{1} l_1/A_1^2 \text{ mm}^{-3}$$

4.5 U Cores of rectangular or round section.

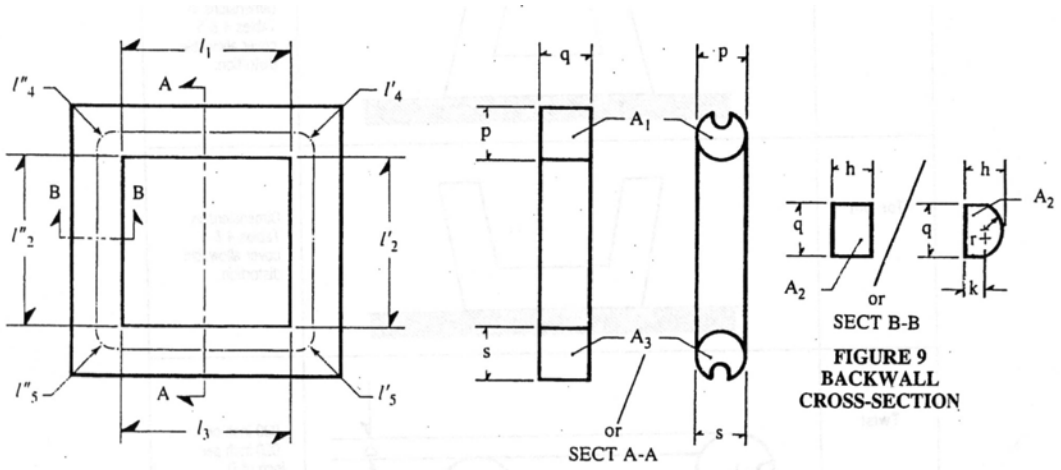


FIGURE 8 U CORES DIVIDED INTO 5 SECTIONS

FIGURE 9 BACKWALL CROSS-SECTION

Path lengths l_1 & l_3 associated with Al_1 & l_3 as shown.

Length of flux path associated with area Al_2 is:

$$\mathbf{1_2 = 1'_2 + 1''_2}\ \text{mm}$$

Mean lengths of flux path at corners are:

$$l_4 = l'_4 + l''_4 = \pi/4(p + h)\ \text{mm}$$

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

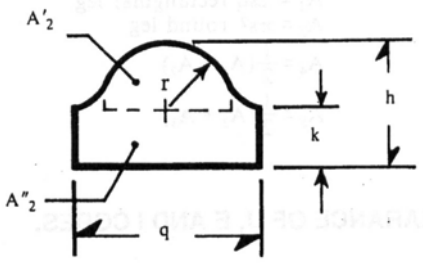
Mean areas associated with l_4 & l_5 are:

$$A_4 = A_1 + A_2 / 2\ \text{mm}^2$$

$$A_5 = A_2 + A_3 / 2\ \text{mm}^2$$

The area associated with *l*. is given by the geometrical cross sectional area or an approximation [or more complex shapes.

One such complex shape is illustrated here as an example:



$$A_2 = A'_2 + A''_2$$

$$A_2 = \frac{\pi r^2}{2} + kq$$

FIGURE 10 BACKWALL CROSS-SECTION

4.6 E Cores

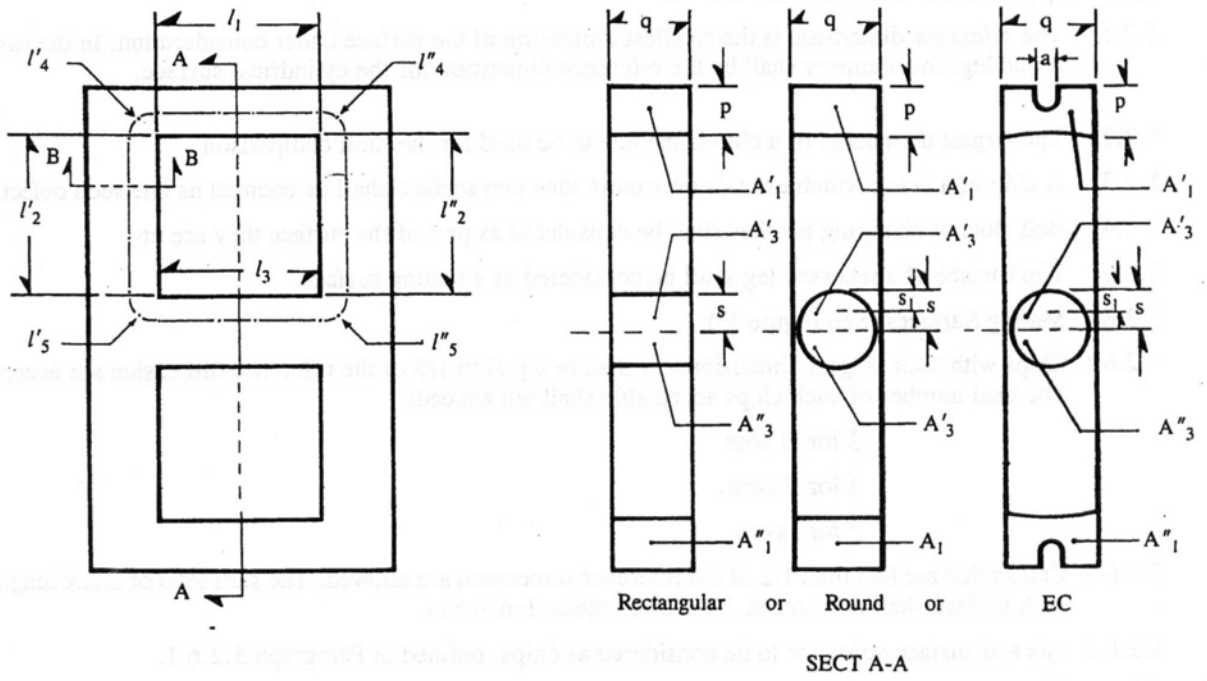


FIGURE 11 E CORES DIVIDED INTO 5 SECTIONS

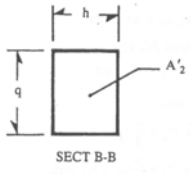


FIGURE 12
BACKWALL CROSS-SECTION

PATH LENGTHS (mm)	**AREAS (mm^2)**
l_1 & l_3 as shown	$A_1 = A'_1 + A''_1$
$l_2 = l'_2 + l''_2$	$A_1 = 2qp$ rectangular leg
$l_4 = l'_4 + l''_4$	$A_1 = 2qp - \Pi a^2/2$ E C Core
$l_4 = \Pi/4\ (p + h)$	$A_2 = A'_2 + A''_2$
$l_5 = l'_5 + l''_4$	$A_2 = 2qh$
$l_5 = \Pi/4\ (s + h)$ rectangular center leg	$A_3 = A'_3 + A''_3$
$l_5 = \Pi/4\ (2s_1 + h)$ round center leg	$A_3 = 2sq$ rectangular leg
Where $s_1 = O.5959s$	$A_3 = \Pi\ s^2$ round leg
	$A_4 = 1/2(A_1 + A_2)$
	$A_5 = 1/2(A_2 + A_3)$

5.0 SURFACE CONDITIONS AND APPEARANCE OF U, E AND I CORES.

5.1 Cleanliness

All mating surfaces of the core should be free of dirt or any other foreign matter. (Any stain, discoloration or surface crazing that does not interfere mechanically or electrically is allowed.)

5.2 Visual appearance of U, E and I cores.

5.2.1 The reference dimension is the smallest dimension of the surface under consideration. In the case of a round leg, the diameter shall be the reference dimension for the cylindrical surface.

5.2.2 The largest dimension of a chip is the one to be used for the limit comparison.

5.2.3 A chip or a crack which extends over more than one surface shall be counted as one such defect.

5.2.4 Bolt slots or clamping notches shall be considered as part of the surface they are on.

5.2.5 The surface of a recessed leg shall be considered as a mating surface.

5.2.6 Mating Surfaces (See Figure 13).

5.2.6.1 Chips with their largest dimension less than or equal to 1/3 of the reference dimension are acceptable. The total number of such chips acceptable shall not exceed:

2 for U core

3 for E core

2 for I core

5.2.6.2 Cracks that are less than 1/2 of the reference dimension are allowed. The sum total of crack lengths for ~ each surface shall not exceed 1/2 the reference dimension.

5.2.6.3 'Pits and surface voids are to be considered as chips, defined in Paragraph *5.2.6.1.*

5.2.7 All non-mating Surfaces. (See Figures 14 and [5).

5.2.7.1 Chips with their largest dimension less than or equal to 1/2 of the reference dimension are allowed. The maximum number of such chips per core is:

7—U core

5—E core

2—I core

5.2.7.2 Cracks, other than corner cracks perpendicular to the flux path, shall not exceed 1/2 of the reference dimension. The total number of such cracks shall not exceed 3.
Cracks parallel to the flux path are acceptable. The total number of such cracks shall not exceed *5.*

Corner cracks shall not exceed 1/4 of the reference dimension. The total number of such cracks shall not exceed 2.
Pits and surface voids are to be considered as chips defined in Paragraph 5.2.7.1.

Pull-outs (See Figure 14). Die pull-outs on a core surface that are less than *25%* of the surface area are acceptable.

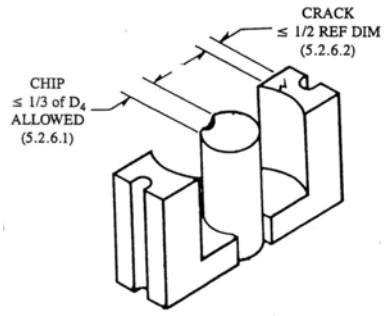


FIGURE 13 CHIPS & CRACKS ON MATING SURFACE

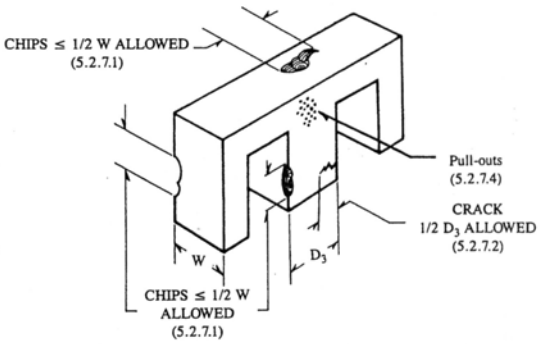


FIGURE 14 CHIPS & CRACKS NON-MATING SURFACES

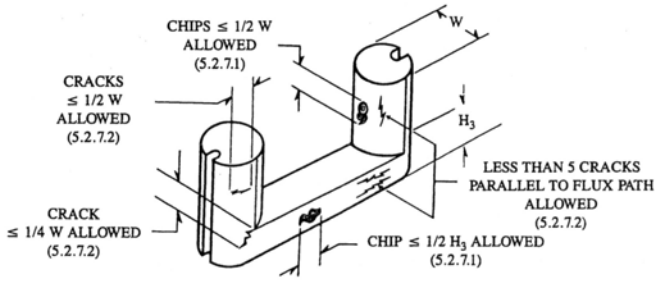


FIGURE 15 CHIPS & CRACKS NON-MATING SURFACES