Power Conversion & Line Filter Applications

Issue L
February 2007

MICROMETALS
IRON POWDER CORES

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RoHS
COMPLIANT
Directive
2002/95/EC

CONTENTS

MICROMETALS, INC. established in 1951, is committed to supplying high quality iron powder cores to meet the needs of the electronics industry. As the technology has changed, new shapes, sizes and materials have been introduced to become industry standards.

MICROMETALS
TEL. (714) 970-9400
FAX (714) 970-0400

INTRODUCTION

Iron powder as a core material has been widely used in RF applications for years. The distributed air gap properties inherent in iron powder cores also make them extremely well-suited for a variety of energy storage inductor applications. Iron powder is a **cost-effective** design alternative to molypermalloy powder (MPP), high flux, or sendust cores. It can also be used in place of ferrites and iron-alloy laminations requiring a gap.

The iron powder cores described in this catalog are typically used for DC output chokes, differential-mode input chokes, power factor correction inductors, continuous-mode flyback inductors, light dimmer chokes and other EMI/RFI applications.

WARRANTY

Parts are warranted to conform to the specifications in the latest issue of this catalog. Micrometals' liability is limited to return of parts and repayment of price; or replacement of nonconforming parts. Notice of nonconformance must be made within 30 days after delivery. Before using these products, buyer agrees to determine suitability of the product for their intended use or application. Micrometals shall not be liable for any other loss or damage, including but not limited to incidental or consequential damages.

GENERAL MATERIAL PROPERTIES

Material Mix No.	Reference Permeability (μ_0)	Material Density (g/cm^3)	Relative Cost	Color* Code
-2	10	5.0	2.7	Red/Clear
-8	35	6.5	5.0	Yellow/Red
-14	14	5.2	3.6	Black/Red
-18	55	6.6	3.4	Green/Red
-19	55	6.8	1.7	Red/Green
-26	75	7.0	1.0	Yellow/White
-30	22	6.0	1.4	Green/Gray
-34	33	6.2	1.5	Gray/Blue
-35	33	6.3	1.4	Yellow/Gray
-40	60	6.9	1.0	Green/Yellow
-45	100	7.2	2.6	Black/Black
-52	75	7.0	1.2	Green/Blue

* All Micrometals color codes are protected by US Trademark law. Formal registration numbers have been issued for the -8, -18, -26 and -52 color codes by the United States Patent and Trademark office.

CORE LOSS COMPARISON (mW/cm^3)

Material Mix No.	60 Hz @5000G	1kHz @1500G	10kHz @500G	50kHz @225G	100kHz @140G	500kHz @50G
-2	19	32	32	28	19	12
-8 **	45	64	59	48	32	15
-14	19	32	32	29	21	17
-18	48	72	70	63	46	37
-19	31	60	72	71	54	49
-26	32	60	75	89	83	139
-30	37	80	120	149	129	129
-34	29	61	87	100	82	78
-35	33	73	109	137	119	123
-40	29	62	93	130	127	223
-45	26	49	60	69	61	92
-52	30	56	68	72	58	63

** Revised since last issue.

PERMEABILITY WITH DC BIAS

HDC = 50 Oersteds

Material Mix No.	%μ_0	$\mu_{effective}$
-2	99	10.0
-8	91	31.9
-14	99	14.0
-18	74	40.7
-19	74	40.7
-26	51	38.3
-30	91	20.0
-34	84	27.7
-35	84	27.7
-40	62	37.2
-45	46	46.0
-52	59	44.3

MATERIAL APPLICATIONS

Typical Application	-2	-8	-14	-18	-19	-26	-30	-34	-35	-40	-45	-52
Light Dimmer Chokes						X				X	X	
60 Hz Differential-mode EMI Line Chokes						X				X	X	X
DC Chokes: <50kHz or low Et/N (Buck/Boost)						X	X	X	X	X	X	
DC Chokes: ≥50kHz or higher Et/N (Buck/Boost)		X	X	X	X		X	X	X			X
Power Factor Correction Chokes: <50kHz						X	X	X	X	X		
Power Factor Correction Chokes: ≥50kHz	X	X	X	X	X		X	X	X			
Resonant Inductors: ≥50kHz	X		X									

MATERIAL DESCRIPTION

-2/-14 Materials The low permeability of these materials will result in lower operating AC flux density than with other materials with no additional gap-loss. The -14 Material is similar to -2 Material with slightly higher permeability.

-8 Material This material has low core loss and good linearity under high bias conditions. A good high frequency material. The highest cost material.

-18 Material This material has low core loss similar to the -8 Material with higher permeability and a lower cost. Good DC saturation characteristics.

-19 Material An inexpensive alternate to the -18 Material with the same permeability and somewhat higher core losses.

-26 Material The most popular material. It is a cost-effective general purpose material that is useful in a wide variety of power conversion and line filter applications.

-30 Material The good linearity, low cost, and relatively low permeability of this material make it popular in large sizes for high power UPS chokes.

-34/-35 Materials An inexpensive alternate to the -8 material for applications where high frequency core loss is not critical. Good linearity with high bias.

-40 Material The least expensive material. It has characteristics quite similar to the very popular -26 Material. Popular in large sizes.

-45 Material The highest permeability material. A high permeability alternate to -52 Material with slightly higher core losses.

-52 Material This material has lower core loss at high frequency and the same permeability as the -26 Material. It is very popular for high frequency choke designs.

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INTRODUCTION

AVAILABILITY

Part numbers in this catalog which appear in **bold** print are considered standard items and are generally available from stock. Other items are available on a build-to-order basis. Orders may be placed directly with the factory in Anaheim, California, or with any of our sales representatives.

Micrometals has factories in Anaheim, California, Abilene, Texas, and Zhongshan, China. In addition Micrometals maintains stocking warehouses in Hong Kong and Dietzenbach, Germany for immediate delivery to the Far East and Europe. The details regarding our warehouses are as follows:

Hong Kong:	**Germany:**
P.Leo & Company Ltd.	BFI Optilas
P.O. Box 175	Assar Gabreilsson Str.1
Fo Tan, Shatin Hong Kong	63128 Dietzenbach Germany
Phone: +852-2604-8222	+49-6074-40980
Fax: +852-2693-2093	+49-6074-4098-10
E-Mail Market@pleo.com	ipe.de@bfioptilas.com

Pricing, delivery and lead-time information as well as technical support are available through our headquarters in Anaheim, California or with any of our local representatives. Please refer to page 69 for complete list of representatives. Also, Micrometals will gladly extend sample cores to aid in your core selection.

CUSTOM SHAPES AND SIZES

In addition to the items shown in this catalog. Micrometals will gladly produce custom shapes and sizes. Several key benefits of iron powder as a core material are; 1) Custom and proprietary tooling are relatively inexpensive, 2) Special prototypes can be machined from blocks of material for preliminary evaluation, and 3) cores can be manufactured in a variety of heights from any of the materials shown without additional tooling charges. Please do not hesitate to contact the factory with any special requests.

ENGINEERING KITS

For a wide selection of cores for engineering design and evaluation, the engineering kits described below are available at a modest charge:

ENGINEERING KIT #14
T20, T25, T26, T30, T37, T38,
T44, T50, T51C, T60, T68, T72, T80,
E49, E75, E100, (Including Bobbins)
42 Items, 425 pieces

ENGINEERING KIT #16
T130, T131, T157, T175, T184, T200, T225,
E162, E168, E187, E220, E225,
(Including Bobbins)
35 Items, 114 pieces

ENGINEERING KIT #15
T80, T90, T106, T130, T131,
E100, E137, E162, (Including Bobbins)
30 Items, 239 pieces

ENGINEERING KIT #17
T225, T250, T300, T400,
E220, E305, E450, (Including Bobbins)
15 Items, 44 pieces

HANDLING AND STORAGE CONSIDERATIONS

Micrometals has designed standard packaging for shipment to customers around the world. We recommend the cores remain in the original factory packaging and be sheltered from rain or high humidity since uncoated iron can eventually form surface rust.

Iron powder cores tend to be heavier than many other products and special consideration must be given to the weight of the carton. (Please refer to page 66 for package increments and weights.) Do not stack more than 5 cartons high to avoid crushing the bottom cartons.

Please be aware the cores are quite dense and package size can be deceivingly heavy. Damage will occur to cores if boxes are handled incorrectly or dropped. Additionally, if individual cores are dropped on a hard surface a crack or chip can result on the core coating.

Special consideration for electrostatic discharge (ESD) is not necessary with iron powder cores since they have a “distributed air gap structure” and will not retain an electrostatic charge.

Finally, as with most magnetic material, iron powder cores need to be kept free of metal shavings, oil, solvents, dirt, dust and acids.

INDUCTANCE RATINGS

In this catalog the inductance ratings, also known as A_L values, are expressed in nanohenries (10^{-9} Henries) per turn (N) squared (nH/N^2). An example of a conversion from mH for 100 turns to nH/N^2 is:

$$350\ \mu H \text{ for } 100 \text{ turns} = 35.0\ nH/N^2$$

To calculate the number of turns required for a desired inductance (L) in nanohenries (nH) use the following formula:

$$\text{Required turns} = \left[\frac{\text{desired L (nH)}}{A_L\ (nH/N^2)}\right]^{1/2}$$

THERMAL CONSIDERATION

Material Mix No.	Temp. Coef. of Permeability (+ppm/C°)	Coef. of Lin. Expansion (+ppm/C°)	Thermal Conductivity (mW/cm-C°)
-2	95	10	10
-8	255	10	29
-14	150	10	11
-18	385	11	21
-19	650	12	30
-26	825	12	42
-30	510	11	20
-34	565	12	28
-35	665	12	30
-40	950	11	36
-45	1043	12	43
-52	650	12	34

TEMPERATURE EFFECTS

Micrometals iron powder cores have an organic content and undergo thermal aging. When cores are exposed to or generate elevated temperatures, a permanent decrease in both inductance and quality factor (Q) will gradually occur. The extent of these changes is highly dependent on time, temperature, core size, frequency, and flux density. It is essential that these properties are considered in any design operating at or above 75°C. Iron powder cores tolerate temperatures down to -65°C with no permanent effects.

In high power applications where core loss is contributing to the total temperature, a decrease in quality factor will translate into an increase in eddy current losses which will further heat the core and can lead to thermal runaway. Designs where core loss exceeds copper loss should be avoided. Hysteresis losses are unaffected by the thermal aging process.

A more thorough and detailed discussion regarding thermal considerations for iron powder core designs is given on pages 38-40 of this catalog. Micrometals has also incorporated a thermal aging predictor into our standard design software. Please contact us directly to receive a free copy or download directly from our web site at http://www.micrometals.com. Furthermore, we are also pleased to provide free design consultation.

FINISH

The toroidal and bus bar cores listed in this catalog are provided with a protective coating. The T14, T16 and T20 size cores are coated under vacuum with Parylene C. The larger cores are coated with a two color code finish that is **UL approved** for Flame Class UL94V-0 per file #E140098 (S). A copy of the Yellow card can be provided upon request. All finishes have a minimum dielectric strength of 500 Vrms at 60 Hz and resist most cleaning solvents. Extended exposure to certain solvents may have detrimental effects.

The toroidal cores can be double or triple coated for greater dielectric strength. We can also provide uncoated cores upon special request. Please contact the factory for information on optional finishes or core caps for larger size toroids. The E-cores and U-cores are treated to help resist rust. Micrometals recommends that all uncoated cores should be sheltered from high humidity or rain since they will eventually form surface rust. Lastly, Micrometals color codes are protected by U.S. trademark law.

MICROMETALS TEL. (714) 970-9400 FAX (714) 970-0400

TOLERANCES

MAGNETIC TOLERANCE

Material (Mix No.)	-2	-8	-14	-18	-19	-26	-30	-34	-35	-40	-45	-52	-267	-275
A_L Tolerance	+5% -5%	+10% -10%	+10% -10%	+10% -10%	+10% -10%	+10% -10%	+10% -10%	+10% -10%	+10% -10%	+10% -10%	+10% -10%	+10% -10%	+35% -25%	+35% -25%

The cores are manufactured to the A_L values listed; the permeability for each material is for reference only. In all cases, **the A_L values are based on a peak AC flux density of 10 gauss (1 mT) at a frequency of 10 kHz**. Measurements made under other conditions will produce results in accordance with the magnetic curves shown on page 27.

The toroidal cores are tested with an evenly-spaced full single-layer winding in order to minimize leakage effects. Iron powder cores tested with a small number of turns which are not evenly distributed will produce higher inductance readings than expected. The E Cores are tested with 100 turns.

The Magnetic Characteristic curves shown on pages 26-27 have a typical tolerance of +20%,-10%. The curves on Core Loss characteristics have a typical tolerance of ±15%.

DIMENSIONAL TOLERANCE (inches)

TOROIDS*	OD	ID	Ht	TOROIDS*	OD	ID	Ht
T14 - T20	±.010	±.010	±.010	**T150 - T225**	±.025	±.025	±.030
T22 - T38	±.015	±.015	±.020	**T249 - T400**	±.030	±.030	±.030
T40 - T72**	±.020	±.020	±.020	**T520 - T650**	±.050	±.050	±.050
T80 - T141	±.020	±.020	±.025				

COMPOSITE*	OD	ID	Ht	COMPOSITE*	OD	ID	Ht
ST50	±.015	±.015	±.020	**ST150**	±.040	±.030	±.030
ST83 - ST102	±.030	±.020	±.025	**ST200**	±.050	±.040	±.040

BUS BAR*	A	B	D	E	L
HS300 - HS400	±.015	±.020	±.005	±.005	±.020

U CORES	A	B	C	E	F	G
U61 - U80	±.010	±.010	±.010	±.010	±.010	±.010
U350	±.020	±.020	±.015	±.020	±.015	±.030

E CORES	A	B	C	D	F	G	Max. Gap***
E49 - E118	±.010	±.010	±.005	±.007	±.005	±.007	.0015
E125 - E162	±.015	±.015	±.007	±.010	±.007	±.010	.0015
E168 - E225	±.015	±.015	±.010	±.010	±.007	±.010	.0020
E305 - E450	±.030	±.030	±.015	±.020	±.015	±.020	.0030
E610	±.040	±.040	±.025	±.030	±.025	±.030	.0050

EH CORES	A	B	C	D	E/H	G	Max. Gap***
EH220	±.015	±.015	±.010	±.020	±.015	±.010	.0030

EM CORES	A	B	C	D	G	H	Max. Gap
EM145	±.015	±.015	±.010	±.020	±.010	±.015	.0020
EM168 - EM220	±.015	±.015	±.010	±.020	±.010	±.015	.0030

PLAIN CORES	OD	L
Pxx24 - Pxx40	+.000/-.005	±.015
Pxx48 - Pxx76	+.000/-.005	±.020

HOLLOW CORES	OD	ID	L
Hx10 - Hx12	+.000/-.005	+.005/-.000	±.010
Hxx14 - Hxx20	+.000/-.005	+.005/-.000	±.015
Hxx21 - Hxx25	+.000/-.005	+.005/-.000	±.020

DISCS	OD	CB	ID	T
D45 - D80	+.000/-.010	+.005/-.000	+.005/-.000	±.007

*Tolerance includes coating

**OD for T50-8/90 and T50-8B/90 is +.025/- .015

***Gap per piece.

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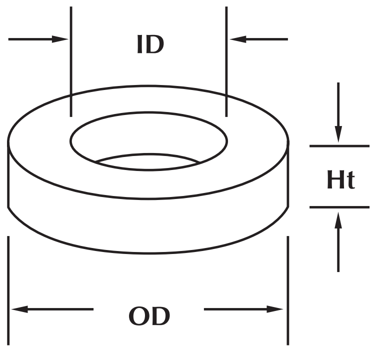
COLOR CODE

-2	Red/Clear
-8	Yellow/Red
-14	Black/Red
-18	Green/Red
-19	Red/Green
-26	Yellow/White
-30	Green/Gray
-34	Gray/Blue
-35	Yellow/Gray
-40	Green/Yellow
-45	Black/Black
-52	Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO.

T 106-26 ___ / ___

- **OD in 100th inches**
- **Micrometals Mix No.**
- **Letter Indicates Alternate Height**
- **Code Area For Other Characteristics**

Note: For information on Mix 0, 1, 3, 4, 6, 7, 10, 12, 15, 17, and 42 see Micrometals RF Catalog.

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS Part No.	A_L nH/N^2	OD in/mm	ID in/mm	Ht in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm^2	V cm^3
T14-26A	12.5	.135/3.43	.067/1.70	.060/1.52	.810	.012	.0098
T14-45A	16.5						
T14-52A	11.5						
T16-2	2.2	.160/4.06	.078/1.98	.060/1.52	.930	.015	.014
T16-8/90	6.0						
T16-18	9.5						
T16-26	14.5						
T16-40	12.5						
T16-45	17.0						
T16-52	13.5						
T20-2	2.5	.200/5.08	.088/2.24	.070/1.78	1.15	.023	.026
T20-8/90	7.8						
T20-18	13.0						
T20-26	18.5						
T20-40	16.0						
T20-45	22.5						
T20-52	17.5						
T22-26	38.5	.223/5.66	.097/2.46	.143/3.63	1.28	.052	.067
T22-52	38.5						
T25-2	3.4	.255/6.48	.120/3.05	.096/2.44	1.50	.037	.055
T25-8/90	10.0						
T25-18	17.0						
T25-26	24.5						
T25-40	20.5						
T25-45	31.0						
T25-52	23.0						
T26-8/90	24.0	.265/6.73	.105/2.67	.190/4.83	1.47	.090	.133
T26-18	41.5						
T26-26	57.0						
T26-45	77.0						
T26-52	56.0						
T27-2	3.3	.280/7.11	.151/3.84	.128/3.25	1.71	.047	.080
T27-8/90	11.5						
T27-18	18.5						
T27-26	27.5						
T27-52	25.5						
T30-2	4.3	.307/7.80	.151/3.84	.128/3.25	1.84	.060	.110
T30-8/90	14.0						
T30-18	22.0						
T30-26	33.5						
T30-40	28.0						
T30-45	40.5						
T30-52	30.5						

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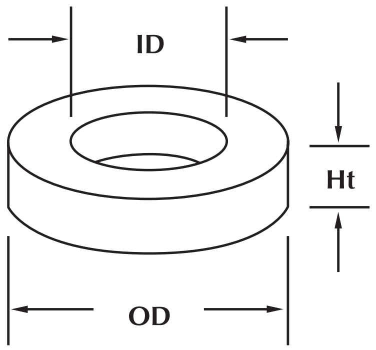
TOROIDAL CORES

COLOR CODE

-2	Red/Clear
-8	Yellow/Red
-14	Black/Red
-18	Green/Red
-19	Red/Green
-26	Yellow/White
-30	Green/Gray
-34	Gray/Blue
-35	Yellow/Gray
-40	Green/Yellow
-45	Black/Black
-52	Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO.

T 106-26 __ / __

- **OD in 100th inches**
- **Micrometals Mix No.**
- **Letter Indicates Alternate Height**
- **Code Area For Other Characteristics**

Note: For information on Mix 0, 1, 3, 4, 6, 7, 10, 12, 15, 17, and 42 see Micrometals RF Catalog.

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS Part No.	AL nH/N²	OD in/mm	ID in/mm	Ht in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm²	V cm³
T32-52	35.0	.327/8.31	.169/4.29	.158/4.01	1.96	.073	.144
T37-2	4.0	.375/9.53	.205/5.21	.128/3.25	2.31	.064	.147
T37-8/90	12.0						
T37-18	19.0						
T37-19	19.0						
T37-26	28.5						
T37-40	24.5						
T37-45	34.0						
T37-52	26.0						
T38-2	7.4	.375/9.53	.175/4.45	.190/4.83	2.18	.114	.248
T38-8/90	20.0						
T38-18	36.0						
T38-19	36.0						
T38-26	49.0						
T38-40	41.5						
T38-45	65.0						
T38-52	49.0						
T40-26	36.0	.400/10.2	.205/5.21	.163/4.14	2.41	.093	.223
T40-52	36.0						
T44-2	5.2	.440/11.2	.229/5.82	.159/4.04	2.68	.099	.266
T44-8/90	18.0						
T44-14	6.2						
T44-18	25.5						
T44-19	25.5						
T44-26	37.0						
T44-40	31.0						
T44-45	46.5						
T44-52	35.0						
T44-52C	55.0	.440/11.2	.229/5.82	.250/6.35	2.68	.157	.419
T44-52D	70.0	.440/11.2	.229/5.82	.338/8.59	2.68	.212	.567
T50-2	4.9	.500/12.7	.303/7.70	.190/4.83	3.19	.112	.358
T50-8/90*	17.5						
T50-14	5.9						
T50-18	24.0						
T50-19	24.0						
T50-26	33.0						
T50-40	29.5						
T50-45	44.0						
T50-52	33.0						

* Non-Standard dimensional tolerance, refer to page 4 for details

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COLOR CODE

-2	Red/Clear
-8	Yellow/Red
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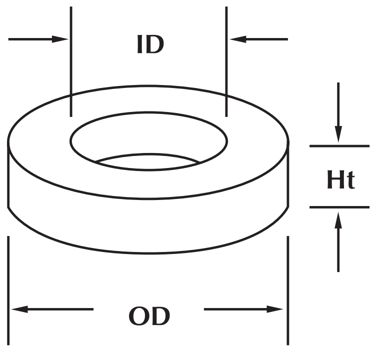
-40	Green/Yellow
-45	Black/Black
-52	Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO.

T 106-26 /

OD in 100th inches
Micrometals Mix No.
Letter Indicates Alternate Height
Code Area For Other Characteristics

Note: For information on Mix 0, 1, 3, 4, 6, 7, 10, 12, 15, 17, and 42 see Micrometals RF Catalog.

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS Part No.	A_L nH/N^2	OD in/mm	ID in/mm	Ht in/mm	ℓ cm	A cm^2	V cm^3
					MAGNETIC DIMENSIONS		
T50-8B/90*	23.0	.500/12.7	.303/7.70	.250/6.35	3.19	.148	.471
T50-18B	32.0						
T50-19B	32.0						
T50-26B	43.5						
T50-40B	38.5						
T50-45B	58.0						
T50-52B	43.5						
T50-8C/90	28.3	.500/12.7	.303/7.70	.335/8.51	3.19	.200	.637
T50-26C	61.0						
T50-26D	72.0	.500/12.7	.303/7.70	.375/9.53	3.19	.223	.711
T50-40D	59.0						
T50-52D	66.0						
T51-8C/90	37.0	.500/12.7	.200/5.08	.250/6.35	2.79	.223	.622
T51-18C	55.0						
T51-26C	83.0						
T51-40C	67.0						
T51-52C	75.0						
T57-45	67.0	.573/14.6	.273/6.93	.196/4.98	3.38	.178	.601
T57-52	49.5						
T57-45A	88.0	.573/14.6	.273/6.93	.263/6.68	3.38	.239	.805
T57-52A	66.0						
T60-2	6.5	.600/15.2	.336/8.53	.234/5.94	3.74	.187	.699
T60-8/90	19.0						
T60-14	8.3						
T60-18	34.5						
T60-19	34.5						
T60-26	50.0						
T60-40	41.5						
T60-52	47.0						
T60-26D	97.0	.600/15.2	.336/8.53	.470/11.9	3.74	.374	1.400
T60-52D	94.0						
T68-2	5.7	.690/17.5	.370/9.40	.190/4.83	4.23	.179	.759
T68-8/90	19.5						
T68-14	7.0						
T68-18	29.0						
T68-19	29.0						
T68-26	43.5						
T68-40	35.0						
T68-45	53.0						
T68-52	40.0						

* Non-standard dimensional tolerance, refer to page 4 for details.

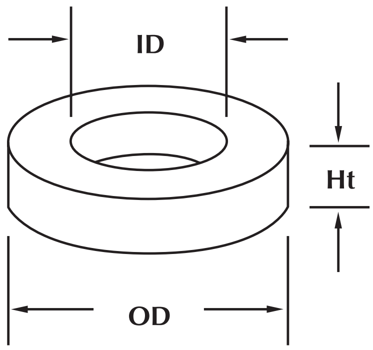
MICROMETALS
TEL. (714) 970-9400
FAX (714) 970-0400

TOROIDAL CORES

COLOR CODE

-2	Red/Clear
-8	Yellow/Red
-14	Black/Red
-18	Green/Red
-19	Red/Green
-26	Yellow/White
-30	Green/Gray
-34	Gray/Blue
-35	Yellow/Gray
-40	Green/Yellow
-45	Black/Black
-52	Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO.

T 106-26 /

OD in 100th inches
Micrometals Mix No.
Letter Indicates Alternate Height
Code Area For Other Characteristics

Note: For information on Mix 0, 1, 3, 4, 6, 7, 10, 12, 15, 17, and 42 see Micrometals RF Catalog.

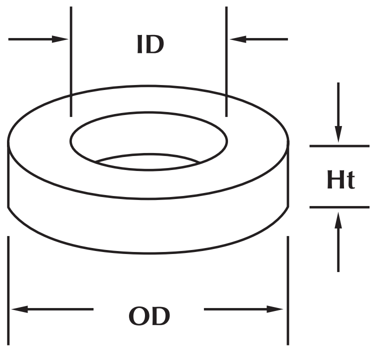
For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS Part No.	AL nH/N^2	OD in/mm	ID in/mm	Ht in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm^2	V cm^3
T68-2A	7.0	.690/17.5	.370/9.40	.250/6.35	4.23	.242	1.03
T68-8A/90	26.0						
T68-14A	9.5						
T68-18A	39.5						
T68-19A	39.5						
T68-26A	58.0						
T68-40A	47.0						
T68-45A	71.0						
T68-52A	54.0						
T68-2D	11.4	.690/17.5	.370/9.40	.375/9.53	4.23	.358	1.52
T68-14D	14.2						
T68-26D	87.0						
T68-40D	70.0						
T68-52D	80.0						
T69-45	120.0	.690/17.5	.336/8.53	.367/9.32	4.09	.394	1.61
T72-2	12.8	.720/18.3	.280/7.11	.260/6.60	4.01	.349	1.40
T72-8/90	36.0						
T72-18	60.0						
T72-26	90.0						
T72-40	71.0						
T72-52	82.0						
T80-2	5.5	.795/20.2	.495/12.6	.250/6.35	5.14	.231	1.19
T80-8/90	18.0						
T80-14	7.4						
T80-18	31.0						
T80-19	31.0						
T80-26	46.0						
T80-40	39.5						
T80-45	56.0						
T80-52	42.0						
T80-8B/90	29.5	.795/20.2	.495/12.6	.375/9.53	5.14	.347	1.78
T80-14B	11.0						
T80-18B	46.5						
T80-19B	46.5						
T80-26B	71.0						
T80-40B	59.0						
T80-45B	84.0						
T80-52B	63.0						
T80-26D	92.0	.795/20.2	.495/12.6	.500/12.7	5.14	.453	2.33
T80-40D	79.0						
T80-52D	83.0						

MICROMETALS
TEL. (714) 970-9400
FAX (714) 970-0400

COLOR CODE
-2 Red/Clear
-8 Yellow/Red
-14 Black/Red
-18 Green/Red
-19 Red/Green
-26 Yellow/White
-30 Green/Gray
-34 Gray/Blue
-35 Yellow/Gray
-40 Green/Yellow
-45 Black/Black
-52 Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO.

T 106-26 /

OD in 100th inches
Micrometals Mix No.
Letter Indicates Alternate Height
Code Area For Other Characteristics

Note: For information on Mix 0, 1, 3, 4, 6, 7, 10, 12, 15, 17, and 42 see Micrometals RF Catalog.

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS Part No.	A_L nH/N^2	OD in/mm	ID in/mm	Ht in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm^2	V cm^3
T90-8/90	30.0	.900/22.9	.550/14.0	.375/9.53	5.78	.395	2.28
T90-18	47.0						
T90-19	47.0						
T90-26	70.0						
T90-40	57.0						
T90-45	85.0						
T90-52	64.0						
T94-2	8.4	.942/23.9	.560/14.2	.312/7.92	5.97	.362	2.16
T94-8/90	25.0						
T94-14	10.0						
T94-18	42.0						
T94-19	42.0						
T94-26	60.0						
T94-40	49.0						
T94-45	76.0						
T94-52	57.0						
T95-26B	84.0	.942/23.9	.495/12.6	.375/9.53	5.72	.510	2.91
T95-52B	84.0						
T106-2	13.5	1.060/26.9	.570/14.5	.437/11.1	6.49	.659	4.28
T106-8/90	45.0						
T106-14	17.0						
T106-18	70.0						
T106-19	70.0						
T106-26	93.0						
T106-30	30.0						
T106-34	40.0						
T106-35	40.0						
T106-40	81.0						
T106-45	125.0						
T106-52	95.0						
T106-18A	49.0	1.060/26.9	.570/14.5	.312/7.92	6.49	.461	3.00
T106-26A	67.0						
T106-40A	58.0						
T106-52A	67.0						
T106-18B	91.0	1.060/26.9	.570/14.5	.575/14.6	6.49	.858	5.57
T106-19B	91.0						
T106-26B	124.0						
T106-40B	106.0						
T106-52B	124.0						
T124-26	58.0	1.245/31.6	.710/18.0	.280/7.11	7.75	.459	3.55
T130-2	11.0	1.300/33.0	.780/19.8	.437/11.1	8.28	.698	5.78
T130-8/90	35.0						
T130-14	14.0						
T130-18	58.0						
T130-19	58.0						

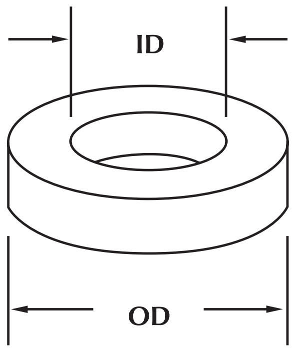
MICROMETALS
TEL. (714) 970-9400
FAX (714) 970-0400

TOROIDAL CORES

COLOR CODE

-2	Red/Clear
-8	Yellow/Red
-14	Black/Red
-18	Green/Red
-19	Red/Green
-26	Yellow/White
-30	Green/Gray
-34	Gray/Blue
-35	Yellow/Gray
-40	Green/Yellow
-45	Black/Black
-52	Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO.

T 106-26 /

OD in 100th inches
Micrometals Mix No.
Letter Indicates Alternate Height
Code Area For Other Characteristics

Note: For information on Mix 0, 1, 3, 4, 6, 7, 10, 12, 15, 17, and 42 see Micrometals RF Catalog.

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

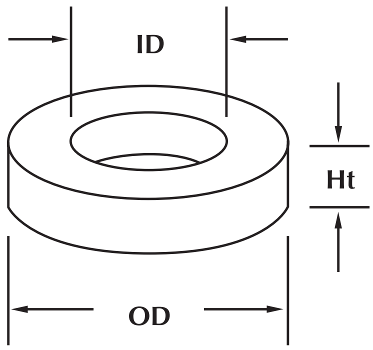
MICROMETALS Part No.	AL nH/N²	OD in/mm	ID in/mm	Ht in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm²	V cm³
T130-26	81.0	1.300/33.0	.780/19.8	.437/11.1	8.28	.698	5.78
T130-30	25.0						
T130-34	33.5						
T130-35	33.5						
T130-40	69.0						
T130-45	105.0						
T130-52	79.0						
T130-26A	41.0	1.300/33.0	.780/19.8	.225/5.72	8.28	.361	2.99
T130-40A	34.0						
T131-8/90	52.5	1.300/33.0	.640/16.3	.437/11.1	7.72	.885	6.84
T131-18	79.0						
T131-19	79.0						
T131-26	116.0						
T131-34	46.5						
T131-35	46.5						
T131-40	93.0						
T131-52	108.0						
T132-26	103.0	1.300/33.0	.700/17.8	.437/11.1	7.96	.805	6.41
T132-40	83.0						
T132-52	95.0						
T141-8/90	32.0	1.415/35.9	.880/22.4	.412/10.5	9.14	.674	6.16
T141-26	75.0						
T141-40	60.0						
T141-52	69.0						
T150-18	65.0	1.510/38.4	.845/21.5	.437/11.1	9.38	.887	8.31
T150-26	96.0						
T150-40	78.0						
T150-52	89.0						
T150-26A	66.0	1.510/38.4	.845/21.5	.325/8.26	9.38	.657	6.16
T150-45A	84.0						
T157-2	14.0	1.570/39.9	.950/24.1	.570/14.5	10.1	1.06	10.7
T157-8/90	42.0						
T157-14	17.5						
T157-18	73.0						
T157-19	73.0						
T157-26	100.0						
T157-30	31.5						
T157-34	43.5						
T157-35	43.5						
T157-40	86.0						
T157-45	130.0						
T157-52	99.0						

MICROMETALS
TEL. (714) 970-9400
FAX (714) 970-0400

COLOR CODE

-2	Red/Clear
-8	Yellow/Red
-14	Black/Red
-18	Green/Red
-19	Red/Green
-26	Yellow/White
-30	Green/Gray
-34	Gray/Blue
-35	Yellow/Gray
-40	Green/Yellow
-45	Black/Black
-52	Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO.

T 106-26 /

OD in 100th inches
Micrometals Mix No.
Letter Indicates Alternate Height
Code Area For Other Characteristics

Note: For information on Mix 0, 1, 3, 4, 6, 7, 10, 12, 15, 17, and 42 see Micrometals RF Catalog.

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS Part No.	AL nH/N²	OD in/mm	ID in/mm	Ht in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm²	V cm³
T175-2	15.0	1.750/44.5	1.070/27.2	.650/16.5	11.2	1.34	15.0
T175-8/90	48.0						
T175-18	82.0						
T175-26	105.0						
T175-40	90.0						
T175-52	105.0						
T184-2	24.0	1.840/46.7	.950/24.1	.710/18.0	11.2	1.88	21.0
T184-8/90	72.0						
T184-14	28.0						
T184-18	116.0						
T184-19	116.0						
T184-26	169.0						
T184-30	51.0						
T184-34	70.0						
T184-35	70.0						
T184-40	143.0						
T184-52	159.0						
T200-2	12.0	2.000/50.8	1.250/31.8	.550/14.0	13.0	1.27	16.4
T200-8/90	42.5						
T200-18	67.0						
T200-19	67.0						
T200-26	92.0						
T200-34	37.0						
T200-35	37.0						
T200-40	79.0						
T200-52	92.0						
T200-2B	21.8	2.000/50.8	1.250/31.8	1.000/25.4	13.0	2.32	30.0
T200-8B/90	78.5						
T200-18B	120.0						
T200-19B	120.0						
T200-26B	160.0						
T200-30B	51.0						
T200-35B	74.0						
T200-40B	142.0						
T200-52B	155.0						
T201-8/90	104.0	2.000/50.8	.950/24.1	.875/22.2	11.8	2.81	33.2
T201-18	164.0						
T201-26	224.0						
T201-40	194.0						
T201-52	224.0						
T224-26C	155.0	2.250/57.2	1.250/31.8	.750/19.1	14.0	2.31	32.2
T224-52C	155.0						
T225-2	12.0	2.250/57.2	1.405/35.7	.550/14.0	14.6	1.42	20.7
T225-8/90	42.5						
T225-18	67.0						
T225-19	67.0						

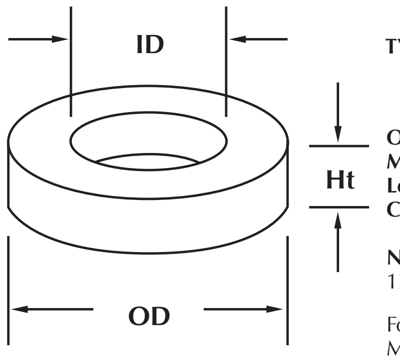
MICROMETALS
TEL. (714) 970-9400
FAX (714) 970-0400

TOROIDAL CORES

COLOR CODE

-2	Red/Clear
-8	Yellow/Red
-14	Black/Red
-18	Green/Red
-19	Red/Green
-26	Yellow/White
-30	Green/Gray
-34	Gray/Blue
-35	Yellow/Gray
-40	Green/Yellow
-45	Black/Black
-52	Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO.

T 106-26 /

OD in 100th inches
Micrometals Mix No.
Letter Indicates Alternate Height
Code Area For Other Characteristics

Note: For information on Mix 0, 1, 3, 4, 6, 7, 10, 12, 15, 17, and 42 see Micrometals RF Catalog.

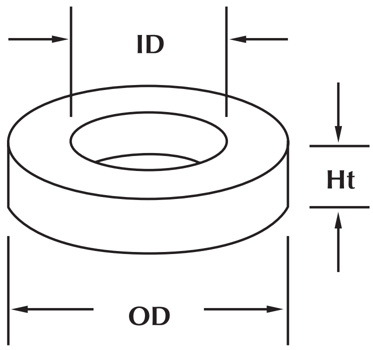
For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS Part No.	A_L nH/N^2	OD in/mm	ID in/mm	Ht in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm^2	V cm^3
T225-26	98.0	2.250/57.2	1.405/35.7	.550/14.0	14.6	1.42	20.7
T225-30	28.0						
T225-34	37.0						
T225-35	37.0						
T225-40	78.0						
T225-52	92.0						
T225-2B	21.5	2.250/57.2	1.405/35.7	1.000/25.4	14.6	2.59	37.8
T225-14B	28.0						
T225-26B	160.0						
T225-34B	67.0						
T225-52B	155.0						
T249-26	203.0	2.500/63.5	1.405/35.7	1.000/25.4	15.6	3.36	52.3
T249-34	89.0						
T249-52	203.0						
T250-8/90	113.0	2.500/63.5	1.250/31.8	1.000/25.4	15.0	3.84	57.4
T250-14	43.0						
T250-18	177.0						
T250-19	177.0						
T250-26	242.0						
T250-30	71.0						
T250-34	106.0						
T250-40	194.0						
T250-52	242.0						
T300-2	11.4	3.040/77.2	1.930/49.0	.500/12.7	19.8	1.68	33.4
T300-8/90	37.0						
T300-18	58.0						
T300-19	58.0						
T300-26	80.0						
T300-30	23.0						
T300-34	34.5						
T300-35	34.5						
T300-40	71.0						
T300-52	80.0						
T300-2D	22.8	3.040/77.2	1.930/49.0	1.000/25.4	19.8	3.38	67.0
T300-14D	28.0						
T300-18D	116.0						
T300-19D	116.0						
T300-26D	160.0						
T300-30D	46.0						
T300-34D	69.0						
T300-35D	69.0						
T300-40D	142.0						
T300-52D	160.0						

MICROMETALS
TEL. (714) 970-9400
FAX (714) 970-0400

COLOR CODE
-2 Red/Clear
-8 Yellow/Red
-14 Black/Red
-18 Green/Red
-19 Red/Green
-26 Yellow/White
-30 Green/Gray
-34 Gray/Blue
-35 Yellow/Gray
-40 Green/Yellow
-45 Black/Black
-52 Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO.

T 106-26 /

OD in 100th inches
Micrometals Mix No.
Letter Indicates Alternate Height
Code Area For Other Characteristics

Note: For information on Mix 0, 1, 3, 4, 6, 7, 10, 12, 15, 17, and 42 see Micrometals RF Catalog.

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

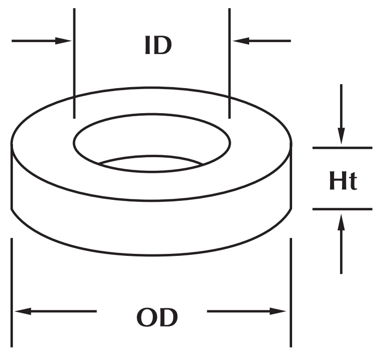
MICROMETALS Part No.	A_L nH/N^2	OD in/mm	ID in/mm	Ht in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm^2	V cm^3
T400-2*	18.0	4.000/102	2.250/57.2	.650/16.5	25.0	3.46	86.4
T400-8/90	60.0						
T400-18	96.0						
T400-19	96.0						
T400-26	131.0						
T400-30	40.5						
T400-34	55.0						
T400-35	55.0						
T400-40	115.0						
T400-52	131.0						
T400-26B*	205.0	4.000/102	2.250/57.2	1.000/25.4	25.0	5.35	133
T400-2D*	36.0	4.000/102	2.250/57.2	1.300/33.0	25.0	6.85	171
T400-14D	45.5						
T400-26D	262.0						
T400-30D	81.0						
T400-34D	110.0						
T400-35D	110.0						
T400-40D	230.0						
T520-2*	20.0	5.200/132	3.080/78.2	.800/20.3	33.1	5.24	173
T520-8/90	65.0						
T520-26	149.0						
T520-30	45.0						
T520-34	65.0						
T520-35	65.0						
T520-40	119.0						
T520-52	137.0						
T520-30D*	90.0	5.200/132	3.080/78.2	1.600/40.6	33.1	10.5	347
T520-34D	130.0						
T520-35D	130.0						
T520-40D	240.0						
T650-2	58.0	6.500/165	3.500/88.9	2.000/50.8	39.9	18.4	734
T650-8/90	200.0						
T650-26	434.0						
T650-30	127.0						
T650-34	191.0						
T650-35	191.0						
T650-40	376.0						
T650-52	405.0						

* T400 and T520 can be provided uncoated by adding the suffix "/18" for use with core covers.
Please refer to page 20 for more details

MICROMETALS
TEL. (714) 970-9400
FAX (714) 970-0400

COMPOSITE CORES

COLOR CODE
-267 Green
-275 Green



Refer to page 4 for tolerances.

TYPICAL PART NO. **ST 102 - 2 75 B**

- **OD in 100th inches**
- **Code to indicate iron powder mix**
- **Indicates percent iron**
- **Letter indicates different Ht.**

MATERIAL COMPOSITION

	Ferrite Core (µ ~ 2300)	Micrometals -52 Material (µ = 75)
-267	33%	67%
-275	25%	75%

Typical Applications: These Ferrite/Iron Powder Composite Cores produce a large change in inductance with DC bias such that 10 to 20 times more inductance will exist at low current than at maximum current. This characteristic is particularly useful for producing DC output chokes for switching power supplies that must maintain continuous operation to very low loads as well as some EMI Filter applications. See page 51 for DC energy storage curves. Micrometals "ST" cores are composed of a ferrite and iron powder core and may contain a small gap or parting line between materials.

MICROMETALS Part No.	A_L nH/N²	OD in/mm	ID in/mm	Ht in/mm	MAGNETIC DIMENSIONS ℓ cm	A* cm²	V cm³
ST50-267	450	.510/13.0	.290/7.37	.280/7.11	3.19	.189	.603
ST50-275B	475	.510/13.0	.290/7.37	.365/9.27	3.19	.246	.786
ST83-267	625	.835/21.2	.510/13.0	.400/10.2	5.37	.398	2.14
ST83-275B	650	.835/21.2	.510/13.0	.525/13.3	5.37	.523	2.81
ST102-267	800	1.025/26.0	.600/15.2	.475/12.1	6.48	.619	4.01
ST102-275B	825	1.025/26.0	.600/15.2	.625/15.9	6.48	.814	5.28
ST150-267	1250	1.520/38.6	.835/21.2	.625/15.9	9.40	1.31	12.3
ST150-275B	1300	1.520/38.6	.835/21.2	.825/21.0	9.40	1.73	16.3
ST200-267	1275	2.010/51.1	1.240/31.5	.775/19.7	13.0	1.83	23.7
ST200-275B	1325	2.010/51.1	1.240/31.5	1.025/26.0	13.0	2.42	31.4

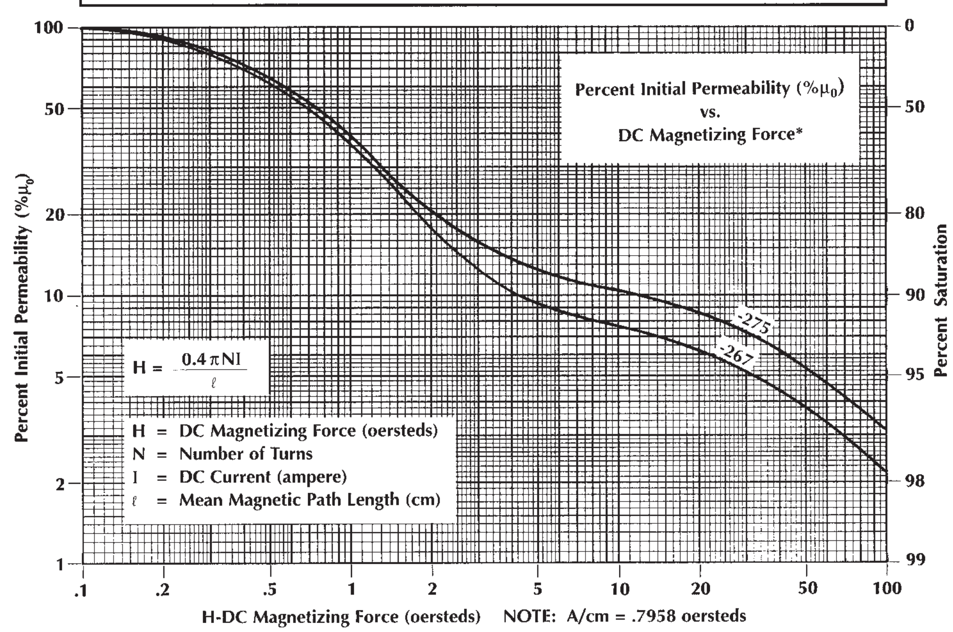
***Combined A**

CURVE FIT FORMULA

$$\%\mu = \frac{(a+cH+eH^2+gH^3+iH^4+kH^5)}{(1+bH+dH^2+fH^3+hH^4+jH^5)}$$

Where: %µ = Percentage (ie:90% =90)
H = DC Magnetizing Force (oersteds)

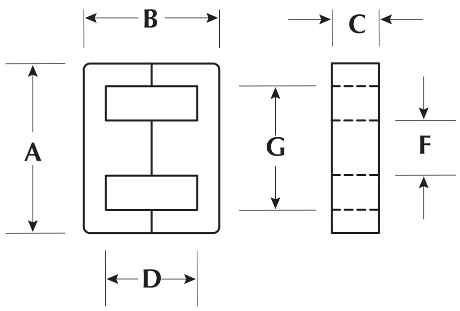
Material	a	b	c	d	e	f	g	h	i	j	k
-267	115	1.11	-17.6	.844	10.7	2.74×10^{-4}	-.359	-7.17×10^{-4}	3.33×10^{-3}	7.50×10^{-6}	-5.30×10^{-6}
-275	113	.999	-9.80	.924	13.1	-2.19×10^{-2}	-.580	-4.31×10^{-4}	5.54×10^{-3}	3.32×10^{-6}	-1.75×10^{-5}



MICROMETALS TEL. (714) 970-9400 FAX (714) 970-0400

COLOR CODE

-2	Red/Clear
-8	Yellow/Red
-14	Black/Red
-18	Green/Red
-19	Red/Green
-26	Yellow/White
-30	Green/Gray
-34	Gray/Blue
-35	Yellow/Gray
-40	Green/Yellow
-45	Black/Black
-52	Green/Blue



TYPICAL PART NO. **E 168 - 26 A / G 015**

"A" dimension in 100th inches (168)
Micrometals Mix No. (26)
Letter Indicates Alternate "C" dimension (A)
Indicates Center-leg gap per half in .001 inches (G 015)

E CORES ORDERED PER HALF

Refer to page 4 for tolerances.
*E-Core sizes from E49 to E100 do not receive color stripes

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS **MAGNETIC DIMENSIONS**

Part No. (Bobbin)	A_L nH/N² (Ref. Size)	A in/mm	B in/mm	C in/mm	D in/mm	F in/mm	G in/mm	ℓ cm	A cm²	V cm³	W cm²
E49-8	20.5	.500/12.7	.437/11.1	.125/3.18	.312/7.93	.125/3.18	.375/9.53	2.86	.101	.288	.252
E49-18	29.0										
E49-26	38.0										
E49-52	38.0										
(PB49)	(US LAM: EE-28-29)										
E50-26	48.0	.505/12.8	.504/12.8	.148/3.76	.354/8.99	.149/3.78	.354/8.99	3.08	.143	.441	.234
E50-52	47.0										
(No Bobbin Offered)	(DIN:13/4)										
E65-8	30.5	.645/16.4	.640/16.3	.182/4.62	.471/12.0	.182/4.62	.445/11.3	3.98	.224	.861	.399
E65-26	58.0										
E65-40	51.0										
E65-52	56.0										
(No Bobbin Offered)	(DIN: 16/5)										
E75-2	14.5	.750/19.1	.635/16.1	.187/4.75	.455/11.6	.187/4.75	.562/14.3	4.20	.226	.936	.551
E75-8	33.5										
E75-26	64.0										
E75-40	55.0										
E75-52	59.0										
(PB75)	(US LAM: EI-187)										
E80-8	38.0	0.795/20.2	.784/19.9	.230/5.84	.550/14.0	.230/5.84	.575/14.6	4.84	.333	1.63	.613
E80-26	73.0										
E80-52	73.0										
(PB80)	(DIN: 20/6)										
E99-8	51.0	1.000/25.4	1.000/25.4	.287/7.29	.690/17.5	.287/7.29	.695/17.7	6.08	.548	3.38	.908
E99-26	96.0										
E99-52	96.0										
(PB99)	(DIN: 25/7)										
E100-2	21.0	1.000/25.4	.750/19.1	.250/6.35	.500/12.7	.250/6.35	.750/19.1	5.08	.403	2.05	.806
E100-8	48.0										
E100-18	65.0										
E100-26	92.0										
E100-40	81.0										
E100-52	85.0										
(PB100E)	(US LAM: EE-24-25)										
E118-26	90.0	1.185/30.1	1.185/30.1	.278/7.06	.782/19.9	.278/7.06	.782/19.9	7.14	.498	4.60	1.27
E118-40	80.0										
E118-52	90.0										
(PB118)	(DIN: 30/7)										

MICROMETALS
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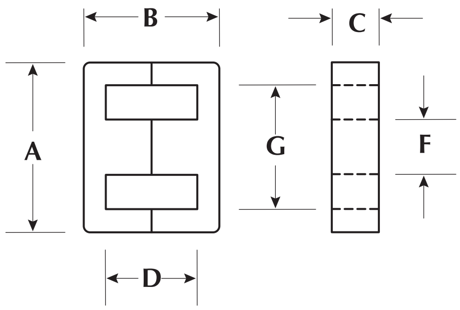
E CORES

COLOR CODE

-2	Red/Clear
-8	Yellow/Red
-14	Black/Red
-18	Green/Red
-19	Red/Green
-26	Yellow/White
-30	Green/Gray
-34	Gray/Blue
-35	Yellow/Gray
-40	Green/Yellow
-45	Black/Black
-52	Green/Blue

Refer to page 4 for tolerances.



TYPICAL PART NO. **E 168 - 26 A / G 015**

"A" dimension in 100th inches
Micrometals Mix No.
Letter Indicates Alternate "C" dimension
Indicates Center-leg gap per half in .001 inches

E CORES ORDERED PER HALF

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS Part No. (Bobbin)	A_L nH/N^2 (Ref. Size)	A in/mm	B in/mm	C in/mm	D in/mm	F in/mm	G in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm^2	V cm^3	W cm^2
E125-26	134.0	1.255/31.8	1.215/30.8	.378/9.60	.835/21.2	.378/9.60	.885/22.5	7.45	.922	6.82	1.37
E125-40	113.0										
(No Bobbin Available)	(US LAM: EE-27-38)										
E137-2	32.0	1.375/34.9	1.145/29.1	.375/9.53	.770/19.6	.375/9.53	1.000/25.4	7.40	.907	6.72	1.55
E137-8	67.0										
E137-18	100.0										
E137-26	134.0										
E137-40	113.0										
E137-52	131.0										
(PB137)	(US LAM: EI-375)										
E145-18	112.0	1.455/37.0	1.370/34.8	.425/10.8	.950/24.1	.425/10.8	1.035/26.3	8.50	1.17	9.89	1.84
E145-26	146.0										
E145-52	146.0										
(No Bobbin Available)											
E162-8	105.0	1.625/41.3	1.342/34.1	.500/12.7	.842/21.4	.500/12.7	1.125/28.6	8.41	1.61	13.6	1.70
E162-18	149.0										
E162-26	210.0										
E162-40	175.0										
E162-52	199.0										
(PB162)	(US LAM: EI-21)										
E168-2	43.5	1.685/42.8	1.660/42.2	.590/15.0	1.210/30.7	.475/12.0	1.210/30.7	10.4	1.81	18.5	2.87
E168-8	97.0										
E168-18	135.0										
E168-26	195.0										
E168-40	163.0										
E168-52	179.0										
(PB168)	(DIN: 42/15)										
E168-26/G015	125.0										
E168-40/G015	114.0										
E168-52/G015	125.0										
Gapped E168 with center gap .030in./.76mm per set											
E168-2A	55.0	1.685/42.8	1.660/42.2	.787/20.0	1.210/30.7	.475/12.0	1.210/30.7	10.4	2.41	24.6	2.87
E168-8A	116.0										
E168-18A	170.0										
E168-26A	232.0										
E168-40A	196.0										
E168-52A	230.0										
(PB168A)	(DIN: 42/20)										
E168-52A/G015	161.0	1.685/42.8	1.660/42.2	.787/20.0	1.210/30.7	.475/12.0	1.210/30.7	10.4	2.41	24.6	2.87
Gapped E168A with center gap .030in./.76mm per set.											

MICROMETALS
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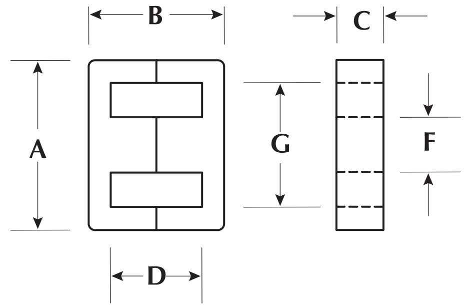
FAX (714) 970-0400

COLOR CODE
- -2 Red/Clear
- -8 Yellow/Red
- -14 Black/Red
- -18 Green/Red
- -19 Red/Green
- -26 Yellow/White
- -30 Green/Gray
- -34 Gray/Blue
- -35 Yellow/Gray
- -40 Green/Yellow
- -45 Black/Black
- -52 Green/Blue



Refer to page 4 for tolerances.

TYPICAL PART NO. **E 168 - 26 A / G 015**

- **"A" dimension in 100th inches** (168)
- **Micrometals Mix No.** (26)
- **Letter Indicates Alternate "C" dimension** (A)
- **Indicates Center-leg gap per half in .001 inches** (G 015)

E CORES ORDERED PER HALF

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS Part No. (Bobbin)	AL nH/N² (Ref. Size)	A in/mm	B in/mm	C in/mm	D in/mm	F in/mm	G in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm²	V cm³	W cm²
E187-8	144.0	1.865/47.4	1.552/39.4	.620/15.7	.952/24.2	.620/15.7	1.250/31.8	9.53	2.48	23.3	1.93
E187-18	213.0										
E187-26	265.0										
E187-40	240.0										
E187-52	265.0										
(PB187)	(US LAM: EI-625)										
E220-2	69.0	2.210/56.1	2.180/55.4	.820/20.8	1.510/38.3	.680/17.3	1.520/38.6	13.2	3.60	47.7	4.09
E220-8	143.0										
E220-18	196.0										
E220-26	275.0										
E220-30	107.0										
E220-34	136.0										
E220-40	240.0										
E220-52	262.0										
(PB220)	(DIN: 55/21)										
E220-26/G020	183.0										
E220-40/G020	168.0										
E220-52/G020	183.0										
Gapped E220 with center gap .040 in./1.02mm per set											
E225-2	76.0	2.240/56.9	1.875/47.6	.745/18.9	1.140/29.0	.745/18.9	1.500/38.1	11.5	3.58	40.8	2.78
E225-8	173.0										
E225-18	240.0										
E225-26	325.0										
E225-40	290.0										
E225-52	325.0										
(PB225)	(US LAM: EI-75)										
E305-2	75.0	3.051/77.5	3.051/77.5	.933/23.7	2.118/53.8	.933/23.7	2.118/53.8	18.5	5.62	104	8.10
E305-8	156.0										
E305-18	222.0										
E305-26	287.0										
E305-30	124.0										
E305-34	150.0										
E305-40	255.0										
E305-52	287.0										
(PB305 or PB305/V0)											
E305-26/G050	165.0										
E305-52/G050	165.0										
Gapped E305 with center gap .100 in./2.54 mm per set											
E305-8A	208.0	3.051/77.5	3.051/77.5	1.244/31.6	2.118/53.8	.933/23.7	2.118/53.8	18.5	7.49	139	8.10
E305-18A	280.0										
E305-26A	382.0										
E305-30A	165.0										
E305-40A	339.0										
E305-52A	382.0										
(PB305A)											

MICROMETALS
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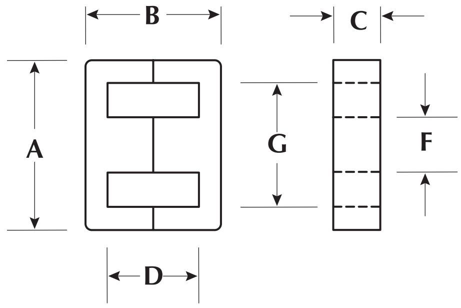
E CORES

COLOR CODE
-2 Red/Clear
-8 Yellow/Red
-14 Black/Red
-18 Green/Red
-19 Red/Green
-26 Yellow/White
-30 Green/Gray
-34 Gray/Blue
-35 Yellow/Gray
-40 Green/Yellow
-45 Black/Black
-52 Green/Blue



TYPICAL PART NO. **E 168 - 26 A / G 015**

"A" dimension in 100th inches
Micrometals Mix No.
Letter Indicates Alternate "C" dimension
Indicates Center-leg gap per half in .001 inches

Refer to page 4 for tolerances.

E CORES ORDERED PER HALF

For information on -60, -61, -63, -66, -70 and -M125 see Micrometals 200C Series Catalog.

MICROMETALS **MAGNETIC DIMENSIONS**

Part No. (Bobbin)	A_L nH/N² (Ref. Size)	A in/mm	B in/mm	C in/mm	D in/mm	F in/mm	G in/mm	ℓ cm	A cm²	V cm³	W cm²
E305-26A/G050	219.0	3.051/77.5	3.051/77.5	1.244/31.6	2.118/53.8	.933/23.7	2.118/53.8	18.5	7.49	139	8.10
E305-52A/G050	219.0										
Gapped E305A with center gap .100 in./2.54 mm per set											
E450-2	132.0	4.500/114	3.636/92.4	1.375/34.9	2.250/57.2	1.375/34.9	3.120/79.3	22.9	12.2	280	12.7
E450-8	260.0										
E450-18	400.0										
E450-26	540.0										
E450-30	235.0										
E450-34	300.0										
E450-40	480.0										
E450-52	500.0										
(PB450/V0)	(US LAM: EI-30)										
E450-8H	140.0	4.500/114	3.636/92.4	.688/17.5	2.250/57.2	1.375/34.9	3.120/79.3	22.9	6.1	140	12.7
E450-18H	200.0										
E450-52H	270.0										
(PB450/V0 for double stack)											
E610-2	163.0	6.102/155	6.102/155	1.866/47.4	4.236/108	1.866/47.4	4.236/108	37.0	22.5	832	32.4
E610-26	588.0										
E610-34	314.0										

BANDING, STRAPPING AND MOUNTING PRECAUTIONS

Iron powder as a core material is susceptible to performance changes when wrapped with a ferrous material. Iron powder cores are manufactured with a distributed air gap and occasionally a center leg gap. When a ferrous material is added to this type of magnetic structure the core is essentially “shorted out” decreasing the overall “Q” of the coil.

This decrease in “Q” indicates an increase in core loss which will result in a higher than expected operating temperature. This effect will be more significant with the lower permeability materials.

Micrometals suggests using the following nonferrous materials to mount and band iron powder cores:

1. Phosphor bronze or nonmagnetic stainless steel banding material
2. Brass hardware
3. Various electrical tapes
4. Cable Tie wraps
5. Filled epoxy or filled super glue

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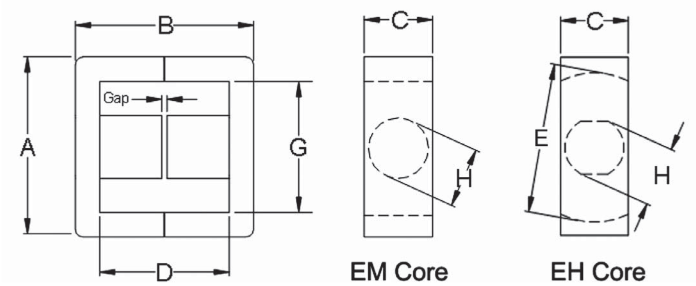

Refer to page 4 for tolerances.
Refer to page 16 and 17 for appropriate "F" Dimensions.

TYPICAL PART NO.

E 168 - 26 A / G 015

"A" dimension in 100th inches
Micrometals Mix No.
Letter Indicates Alternate "C" dimension
Indicates Center-leg gap per half in .001 inches

EH AND EM CORES ORDERED PER HALF

MICROMETALS Part No.	A_L Value nH/N²	A in/mm	B in/mm	C in/mm	D in/mm	E in/mm	G in/mm	H in/mm	ℓ cm	A cm²	V cm³
									MAGNETIC DIMENSIONS		
EH220-8	114.0	2.210/56.1	2.180/55.4	0.820/20.8	1.510/38.3	1.700/43.2	1.520/38.6	0.780/19.8	13.3	2.19	29.1
EH220-40/13	191.0										
EH220-40/G070/13	76.4	2.210/56.1	2.180/55.4	0.820/20.8	1.510/38.3	1.700/43.2	1.520/38.6	0.780/19.8	13.3	2.19	29.1

Gapped EH220 with center gap. .140 in./3.56mm per set.

MICROMETALS Part No.	A_L Value nH/N²	A in/mm	B in/mm	C in/mm	D in/mm	G in/mm	H in/mm	ℓ cm	A cm²	V cm³
								MAGNETIC DIMENSIONS		
EM102-8	40.1	1.000/25.4	1.000/25.4	0.500/12.7	0.800/20.3	0.800/20.3	0.350/8.89	6.28	0.637	4.00
EM102-52	84.8									
EM126-8	48.7	1.250/31.8	1.250/31.8	0.570/14.5	0.916/23.3	1.010/25.7	0.438/11.1	7.46	0.960	7.43
EM126-52	119.0									
EM126-52/G040	49.9									
Gapped EM126 with center gap .080 in./2.03mm per set.										
EM145-26	125.0	1.455/37.0	1.370/34.8	0.425/10.8	0.950/24.1	1.035/26.3	0.425/10.8	8.50	0.915	9.28
EM145-52	125.0									
EM150-8	63.7	1.500/38.1	1.500/38.1	0.750/19.1	1.200/30.5	1.190/30.2	0.536/13.6	9.46	1.45	13.7
EM150-52	127.0									
EM169-8	82.3	1.685/42.8	1.654/42.0	0.766/19.5	1.204/30.6	1.360/34.5	0.580/14.7	9.90	1.79	17.7
EM169-40/13	148.0									
EM169-52	151.0									
EM169-40/G052/13	61.3									
Gapped EM169 with center gap .104 in./2.64mm per set.										
EM193-8	77.0	1.930/49.0	1.930/49.0	0.877/22.3	1.530/38.9	1.530/38.9	0.676/17.2	12.1	2.28	27.5
EM193-52	168.0									
EM193-40/G060/13	70.6									
Gapped EM193 with center gap .120 in./3.05mm per set.										
EM220-26*	230.0	2.210/56.1	2.180/55.4	.820/20.8	1.510/38.3	1.520/38.6	0.780/19.8	13.2	2.90	45.0
EM220-40	196.0									
EM220-26/G020	173.0									
EM220-40/G020	143.0									
Gapped EM220 with center gap .040 in./1.02mm per set.										
EM221-8	89.9	2.210/56.1	2.200/55.9	1.070/27.2	1.760/44.7	1.760/44.7	0.850/21.6	13.7	3.22	44.0
EM221-40/13	188.0									
EM221-52	228.0									

* Center post not completely round on EM220 series.

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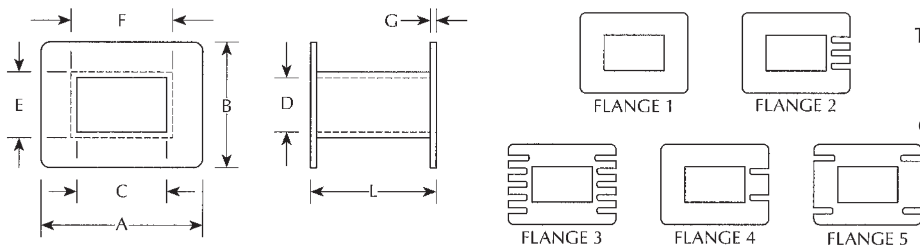
E CORE BOBBINS



TYPICAL PART NO.

PB 168A

Corresponds to E Core

Typical Tolerance ± .010

Material: 6/6 Nylon
PB305, P305A 6/6 Nylon Glass Filled

Bobbin Notes: All bobbins are composed of 6/6 Nylon material except PB305, PB305A and any bobbin with the suffix "/V0". The PB305 and PB305A are composed of 6/6 Nylon Glass Filled. The "/V0" indicates a material that is rated for UL 94 V0 flame class. Micrometals also offers bobbins for the following metric and custom E-core sizes for sample and small quantity orders; E80, E99. Their part numbers are, respectively, PB80, and PB99.

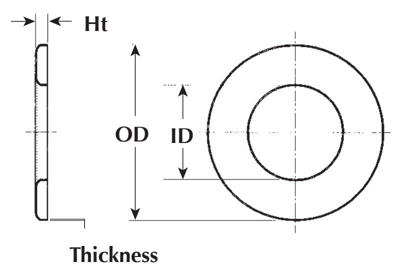
MICROMETALS Part No.	A in/mm	B in/mm	C in/mm	D in/mm	L in/mm	E in/mm	F in/mm	G in/mm	Flange No.
PB49	.360/9.14	.360/9.14	.130/3.30	.130/3.30	.307/7.80	.160/4.06	.160/4.06	.020/.508	1
PB75	.535/13.6	.535/13.6	.205/5.21	.205/5.21	.420/10.7	.250/6.35	.250/6.35	.025/.635	1
PB100E	.740/18.8	.740/18.8	.265/6.73	.265/6.73	.475/12.1	.305/7.75	.305/7.75	.035/.889	1
PB137	.865/22.0	.865/22.0	.385/9.78	.385/9.78	.680/17.3	.445/11.3	.445/11.3	.032/.813	1
PB162	1.100/27.9	1.100/27.9	.510/13.0	.510/13.0	.796/20.2	.575/14.6	.575/14.6	.032/.813	1
PB168	1.370/34.8	1.165/29.9	.640/16.3	.490/12.4	1.150/29.2	.570/14.5	.720/18.3	.060/1.52	2
PB168A	1.465/37.2	1.157/29.4	.799/20.3	.492/12.5	1.142/29.0	.570/14.5	.880/22.4	.060/1.52	3
PB187	1.215/30.9	1.225/31.1	.645/16.4	.645/16.4	.925/23.5	.715/18.2	.715/18.2	.025/.635	4
PB220	1.640/41.7	1.425/36.2	.840/21.3	.680/17.3	1.440/36.6	.760/19.3	.920/23.4	.060/1.52	2
PB225	1.480/37.6	1.480/37.6	.765/19.4	.765/19.4	1.115/28.3	.845/21.5	.845/21.5	.035/.889	5
PB305	2.020/51.3	2.020/51.3	.965/24.5	.965/24.5	2.040/51.8	1.055/26.8	1.055/26.8	.060/1.52	2
PB305/V0	2.020/51.3	2.020/51.3	.965/24.5	.965/24.5	2.040/51.8	1.055/26.8	1.055/26.8	.060/1.52	2
PB305A	2.330/59.2	2.020/51.3	1.275/32.4	.965/24.5	2.040/51.8	1.055/26.8	1.365/34.7	.060/1.52	2
PB450/V0	3.050/77.5	3.050/77.5	1.412/35.9	1.412/35.9	2.200/55.9	1.544/39.2	1.544/39.2	.066/1.68	1

TOROIDAL CORE CAPS

TYPICAL PART NO.

TC 400

Corresponds to Toroid



Typical thickness tolerance ± .005
Specified dimensions for reference only.
Material type: Rynite FR530 (UL 94V-Ø)
UL Yellow Card: #E69578

Typical Applications: The toroidal core caps can be used as an alternate to the standard insulating coating when winding cores with very heavy gauge wire or when a greater dielectric strength is required. Core caps will fit either coated or uncoated cores. To specify a core that is uncoated add the suffix "/18" to standard part numbers. (Example: T400-26 is a standard part which includes coating, T400-26/18 specifies a standard part without coating.)

MICROMETALS PART NO.	OD in/mm	ID in/mm	Ht in/mm	THICKNESS in/mm
TC400	4.030/102.4	2.235/56.8	.250/6.35	.030/.762
TC520	5.250/133.4	3.062/77.8	.250/6.35	.030/.762

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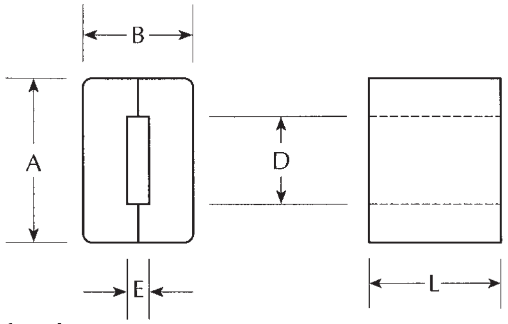
COLOR CODE
-8 Red
-26 Yellow
-52 Green



TYPICAL PART NO. **HS 300 - 26 A /**

Code To Indicate Max. Current
Micrometals Mix No.
Letter Indicates Alternate Length
Code Area For Other Characteristics

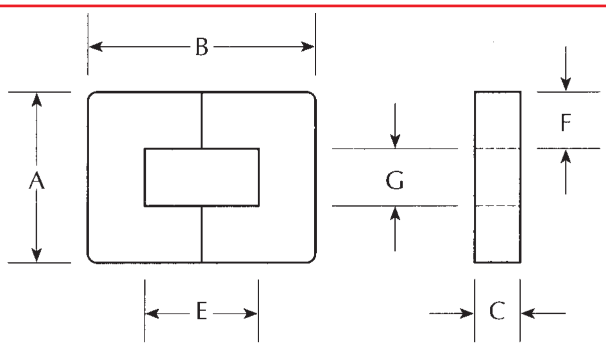
Refer to page 4 for tolerances.

HS CORES ORDERED PER HALF

MICROMETALS Part No.	AL* nH/N²	A in/mm	B in/mm	L in/mm	D in/mm	E in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm²	V cm³
HS300-8	68	1.020/25.9	.650/16.5	.500/12.7	.520/13.2	.140/3.56	5.92	.806	4.61
HS300-26	147								
HS300-52	147								
HS300-8A	83	1.020/25.9	.650/16.5	.625/15.9	.520/13.2	.140/3.56	5.92	1.01	5.77
HS300-26A	179								
HS300-52A	179								
HS300-8B	95	1.020/25.9	.650/16.5	.750/19.1	.520/13.2	.140/3.56	5.92	1.21	6.92
HS300-26B	208								
HS300-52B	208								
HS300-8C	107	1.020/25.9	.650/16.5	.875/22.2	.520/13.2	.140/3.56	5.92	1.41	8.06
HS300-26C	232								
HS300-52C	232								
HS400-26	221	1.500/38.1	.960/24.4	.750/19.1	.765/19.4	.205/5.21	8.71	1.78	15.1
HS400-26A	286			1.000/25.4				2.37	20.1
HS400-26B	335			1.250/31.8				2.96	25.2
HS400-26C	371			1.500/38.1				3.56	30.2

*Based on 25 turn test winding

U CORES



TYPICAL PART NO. **U 80 - 26 A /**

"A" dim to 1000th inches
Micrometals Mix No.
Letter Indicates Alternate "C" dim.
Code Area For Other Characteristics

Refer to page 4 for tolerances.

U CORES ORDERED PER HALF

MICROMETALS Part No.	AL nH/N²	A in/mm	B in/mm	C in/mm	E in/mm	F in/mm	G in/mm	MAGNETIC DIMENSIONS ℓ cm	A cm²	V cm³
U61-26	71.0	.610/15.5	.900/22.9	.250/6.35	.510/13.0	.195/4.95	.210/5.33	5.66	.315	1.81
U80-8	42.4	.800/20.3	1.250/31.8	.250/6.35	.750/19.1	.250/6.35	.300/7.62	7.87	.403	3.18
U80-26	71.0									
U80-40	64.0									
U80-52	70.0									
U350-2	59.0	3.500/88.9	5.750/146	1.000/25.4	3.250/82.6	1.000/25.4	1.500/38.1	35.6	6.45	250
U350-40	235.5									

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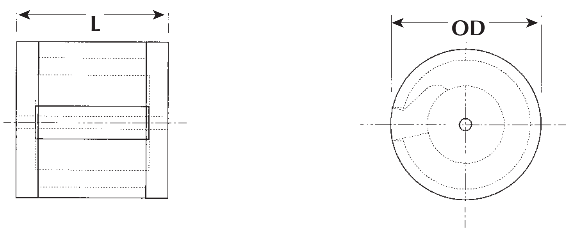
POT CORE ASSEMBLIES

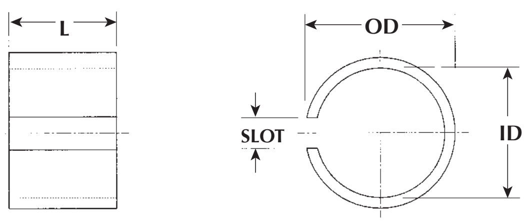


The Pot Core Assemblies provide a closed-path structure for high current designs where the round winding form and efficient packaging shape are beneficial. The geometry also provides the added flexibility of using lower permeability materials for the hollow core instead of gapping the structure.

Typical assemblies are illustrated. This configuration is not available assembled. Order 2 Disks, 1 Hollow Core and 1 sleeve per set.

SLEEVE Part No.	DISC Part No.	HOLLOW CORE Part No.	AL nH/N²	OD in/mm	L in/mm	Window cm²	ℓ cm	A cm²	V cm³
S101-1002	D101-1002	H2526-1002	165.8*	3.150/80.0	2.402/61.0	5.49	15.3	12.7	204
S101-1040	D101-1040	H2526-1040	600*						

SLEEVE



TYPICAL PART NO.

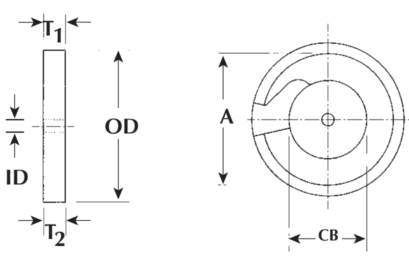
S 101-10 40

OD in 100th inches
Code area for other characteristics
Micrometals Mix No.

Typical Tolerance ± .050 inches

SLEEVE Part No.	OD in/mm	ID in/mm	L in/mm	Slot in/mm
S101-1002	3.150/80.0	2.680/68.1	1.615/41.0	.760/19.3
S101-1040				

DISC



TYPICAL PART NO.

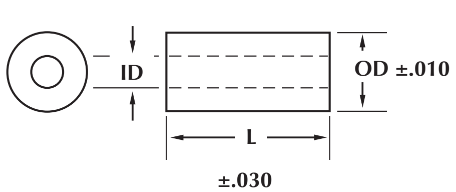
D 101-10 40

OD in 100th inches
Code area for other characteristics
Micrometals Mix No.

Typical Tolerance ± .030 inches

DISC Part No.	OD in/mm	CB in/mm	ID in/mm	T_1 in/mm	T_2 in/mm	A in/mm
D101-1002	3.150/80.0	1.614/41.0	.250/6.35	.394/10.0	.374/9.50	2.675/67.9
D101-1040						

HOLLOW CORE



TYPICAL PART NO.

H 25 26 -10 40

OD in 16th inches
Length in 16th inches
Code area for other characteristics
Micrometals Mix No.

HOLLOW CORE Part No.	OD in/mm	ID in/mm	L in/mm
H2526-1002	1.600/40.6	.250/6.35	1.615/41.0
H2526-1040			

***AL value is approximate and is for indication only**

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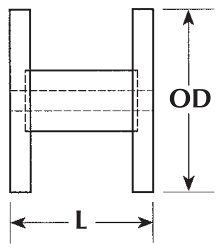
BOBBIN ASSEMBLIES



Various bobbins can be assembled from the Hollow Cores and Disks shown on the following page. These bobbin assemblies provide an alternative shape for high current choke applications which can tolerate some electro-magnetic radiation. This configuration can be especially effective for high power speaker crossover coils.

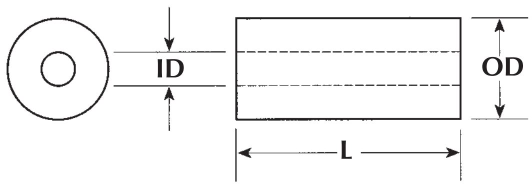
Typical assemblies are illustrated. This configuration is not available assembled. Order 2 Disks and one Hollow Core per set.

DISC Part No.	HOLLOW Core Part No.	AL* nH/N2	OD in/mm	L in/mm	WINDOW in/mm
D45-1040	**H811-1140**	85	1.420/36.1.	937/23.8	1.84
D45-1040	H817-1140	60	1.420/36.1	1.312/33.3	2.95
D59-1040	H1015-1040	100	1.845/46.9	1.250/31.8	3.43
D59-1040	H1021-1040	80	1.845/46.9	1.625/41.3	4.90
D80-2040	H1217-1040	130	2.500/63.5	1.375/34.9	5.66
D80-2040	**H1225-1040**	95	2.500/63.5	1.875/47.6	8.49

* AL value listed is approximate and is for indication only

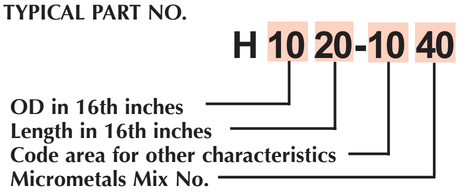
HOLLOW CORES

Core outside and inside diameters listed are standard with cariations in length possible upon request.



Refer to page 4 for tolerances.

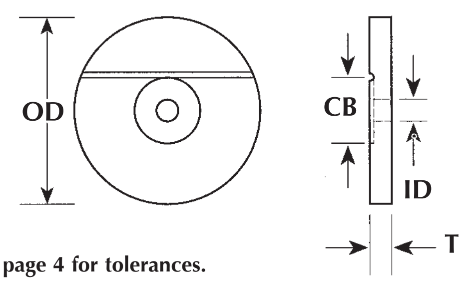
TYPICAL PART NO.



Note: For information on Mix 1, 3, 4, 6, 7, 10, 12, 15, 17, 42, and 0 see **Micrometals RF Catalog**

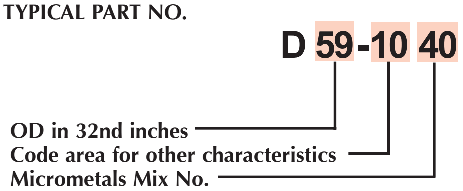
MICROMETALS Part. No.	OD in/mm	ID in/mm	Length in/mm
H512-1026	.312/7.95	.137/3.48	.750/19.1
H811-1140	.500/12.7	.172/4.37	.688/17.5
H817-1140	.500/12.7	.172/4.37	1.064/27.0
H822-1140	.500/12.7	.172/4.34	1.375/34.9
H1014-1040	.625/15.9	.219/5.56	.900/22.9
H1015-1040	.625/15.9	.219/5.56	.955/24.3
H1020-1040	.625/15.9	.219/5.56	1.250/31.8
H1021-1040	.625/15.9	.219/5.56	1.330/33.8
H1217-1040	.750/19.1	.260/6.60	1.080/27.4
H1225-1040	.750/19.1	.260/6.60	1.580/40.1
H1616-1040	1.000/25.4	.250/6.35	1.000/25.4

DISCS



Refer to page 4 for tolerances.

TYPICAL PART NO.



Variations in T are available upon request.

Variations in CB possible with a modest tooling charge.

MICROMETALS Part No.	OD in/mm	CB in/mm	ID in/mm	T in/mm
D45-1040	1.420/36.1	.500/12.7	.172/4.37	.156/3.96
D59-1040	1.845/46.9	.635/16.1	.188/4.78	.187/4.75
D80-2040	2.500/63.5	.755/19.2	.255/6.48	.187/4.75

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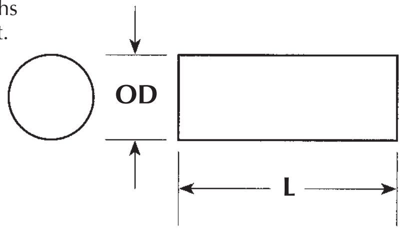
PLAIN CORES

Core diameters are standard with variations from listed core lengths possible upon request.



TYPICAL PART NO.

P 16 32 -1 40

- **OD in 64th inches** — 16
- **Length in 32nd inches** — 32
- **Code area for other characteristics** — 1
- **Micrometals Mix No.** — 40

Note: For information on Mix 1, 3, 4, 6, 7, 10, 12, 15, 17, 42, and 0 see **Micrometals RF Catalog**

MICROMETALS Part No.	A_L* nH/N^2	OD in/mm	Length in/mm
P816-340	8.0	.134/3.40	.500/12.7
P1224-140	12.5	.190/4.83	.750/19.1
P1624-140	16.0	.250/6.35	.750/19.1
P1632-140	16.0	.250/6.35	1.000/25.4
P1640-240	15.0	.255/6.48	1.250/31.8
P2032-240	20.0	.313/7.95	1.000/25.4
P2040-240	20.0	.313/7.95	1.250/31.8
P2432-240	25.5	.375/9.53	1.000/25.4
P2440-240	26.5	.375/9.53	1.250/31.8
P2448-240	25.0	.375/9.53	1.500/38.1
P2456-240	22.5	.375/9.53	1.750/44.5
P3240-140	34.5	.500/12.7	1.250/31.8
P3248-140	33.0	.500/12.7	1.500/38.1
P3256-140	32.0	.500/12.7	1.750/44.5
P3264-140	31.0	.500/12.7	2.000/50.8
P4040-140	37.5	.625/15.9	1.250/31.8
P4048-140	41.5	.625/15.9	1.500/38.1
P4876-140	49.5	.750/19.1	2.375/60.3
P6464-140	80.0	1.000/25.4	2.000/50.8

* **AL** is approximate and for reference only

CYLINDERICAL CORE APPLICATIONS

The inductance and required number of turns for cylindrical shapes such as plain and hollow cores can be closely approximated from the following equations:

SINGLE-LAYER COIL

$$L = \frac{\mu_{eff}\,(rN)^2}{9r + 10\ell}$$

or

$$N = \frac{1}{r}\left[\frac{L(9r + 10\ell)}{\mu_{eff}}\right]^{1/2}$$

MULTI-LAYER COIL

$$L = \frac{(0.8)(\mu_{eff})(rN)^2}{6r + 9\ell + 10b}$$

or

$$N = \frac{1}{r}\left[\frac{L(6r + 9\ell + 10b)}{(0.8)(\mu_{eff})}\right]^{1/2}$$

WHERE:

L = Inductance

μ_{eff} = Effective permeability of core (See graph below)

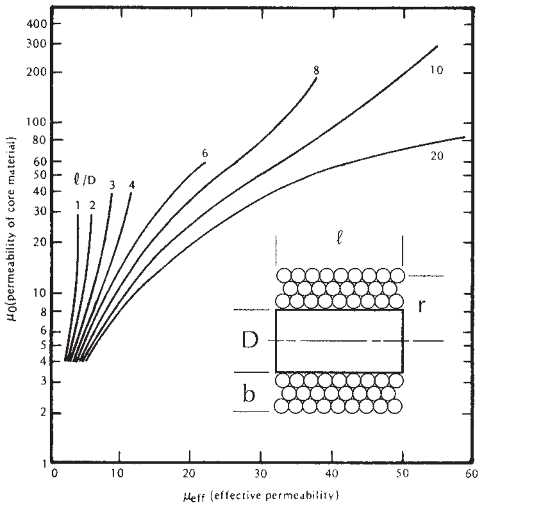
N = Number of turns

r = Radius of coil (inches)

D = Diameter of core (inches)

ℓ = Length of coil/core (inches)

b = Coil build



The family of curves to the left shows how the effective premeability (μ_{eff}) of a wound clyindrical core is a function of the core's wound length to diameter ratio (ℓ/D)as well as the initial material permeability (μ_{eff}).

These curves indicate that in many cases variations in the length/diameter ratio will more significantly affect the effective permeability than increases in permeability of the core material.

This group of curves was calculated using a cylindrical core with a single layer winding closely wound over 95% of its length. It is also possible to use as a fair approximation of the effective permeability for multi-layer windings.

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INTRODUCTION TO MAGNETIC CHARACTERISTICS

General Information: The magnetic characteristics shown on pages 26-36 result from testing toroidal cores. The magnetization curves on pages 26 and 27 have a typical tolerance of +20%, -10%. Other configurations such as E Cores and U Cores will produce slightly different results due to the effects of leakage associated with the geometry.

These characteristics were measured at room temperature. The temperature coefficient of initial permeability for each material is listed on page 3. The temperature coefficient of percent permeability versus both DC magnetizing force and peak AC flux density ranges from -100 to -400 ppm/C°. The combination of these coefficients will generally result in an increase in inductance with increasing temperature even under biased conditions.

The percent change in permeability is directly proportional to the percent change in A_L value. The cores are manufactured to the A_L value rather than to the referenced permeability.

Since iron powder cores are normally used in inductor applications the magnetization curves provided on page 26 and 27 are in relation to permeability. B-H curves are shown below.

DC Magnetization: The curves at the bottom of page 26 illustrate the effect of DC Magnetizing force on percent initial permeability for the materials shown. As the level of DC magnetizing force increases, the materials gradually experience a reduction in permeability. This "soft" saturation characteristic results from the distributed air-gap in the iron powder core materials.

The formula in the body of the graph is used to calculate the DC Magnetizing Force in oersteds. The mean magnetic path (ℓ) for each core is included in the part number listing.

These curves are based on a peak AC flux density of 10 gauss (1 mT). The response to DC magnetizing force is affected by the level of peak AC flux density present.

AC Magnetization: The curves at the top of page 27 illustrate the effect of Peak AC Flux Density on percent initial permeability. As the level of peak AC flux density increases, the materials experience an increase in permeability up to an AC flux density of between 3000 and 6000 gauss. Beyond this level, the material begins to saturate. These curves are the result of tests performed from 60 Hz to 10 kHz.

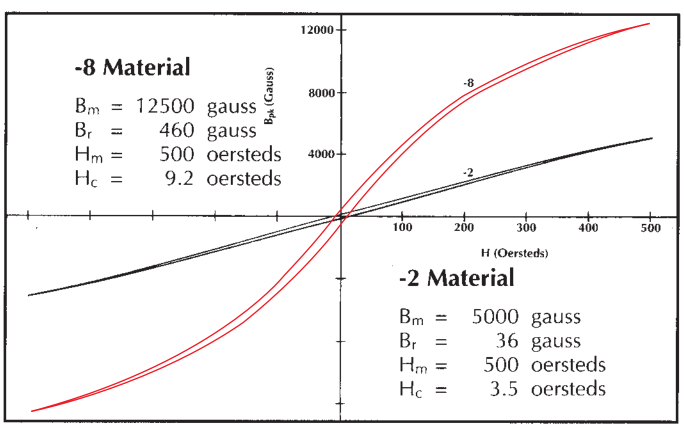
The formula in the body of the graph is used to calculate the peak AC flux density in gauss. The Cross-Sectional Area (A) for each core is included in the part number listing.

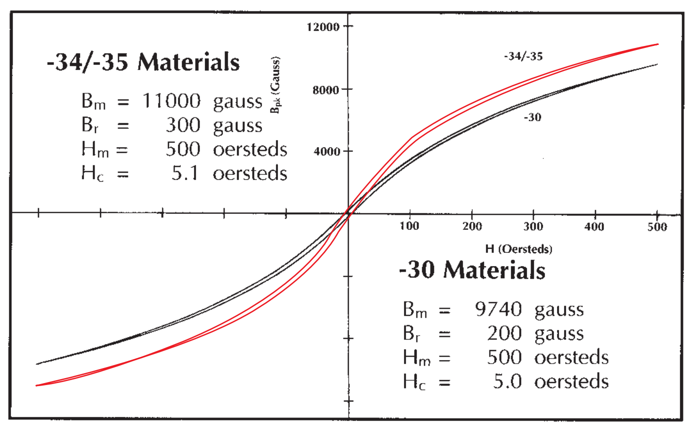
The A_L values listed are based on a peak AC flux density of 10 gauss (1 mT). Testing cores at a higher flux density can have a significant effect on measured results.

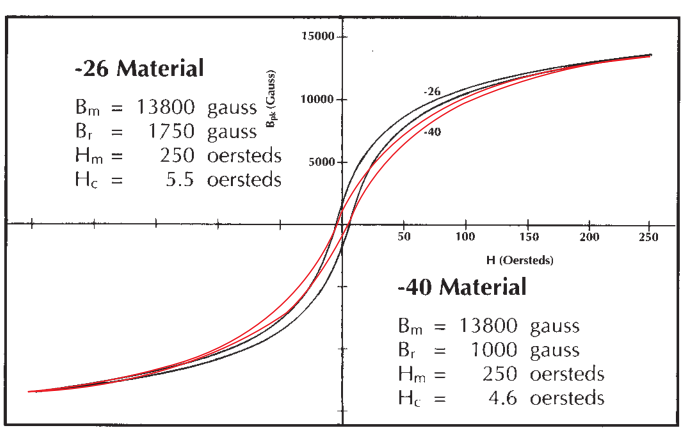
Frequency Response: The curves at the bottom of page 27 show how the permeability of each material is affected by frequency.

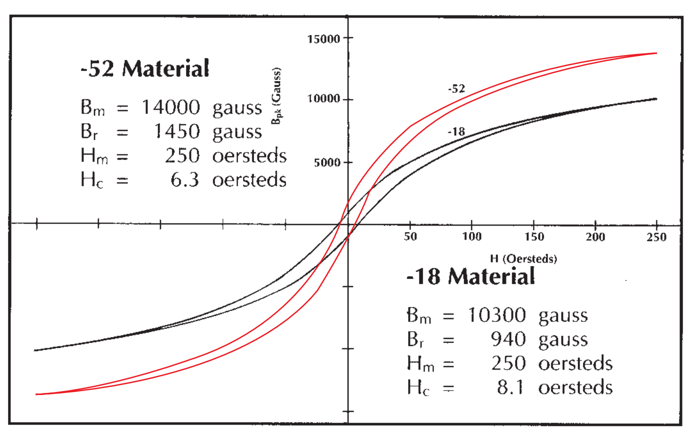
A typical coil wound with multiple turns will have a measurable amount of interwinding capacitance which acts in parallel with the coil. This interwinding capacitance will cause the coil to become self-resonant. In order to avoid this effect, the data at the highest frequencies was taken with a single turn.

BH CURVES









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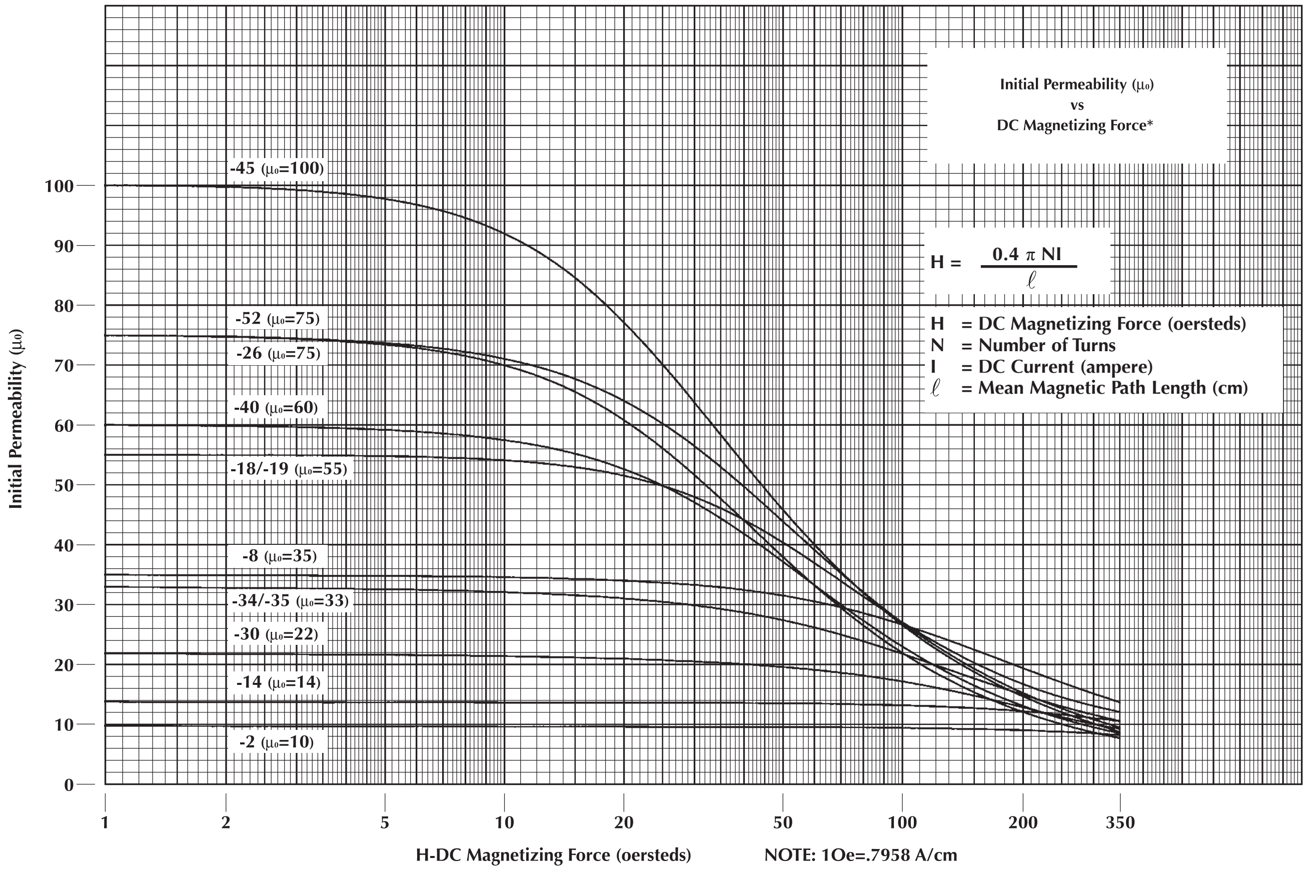
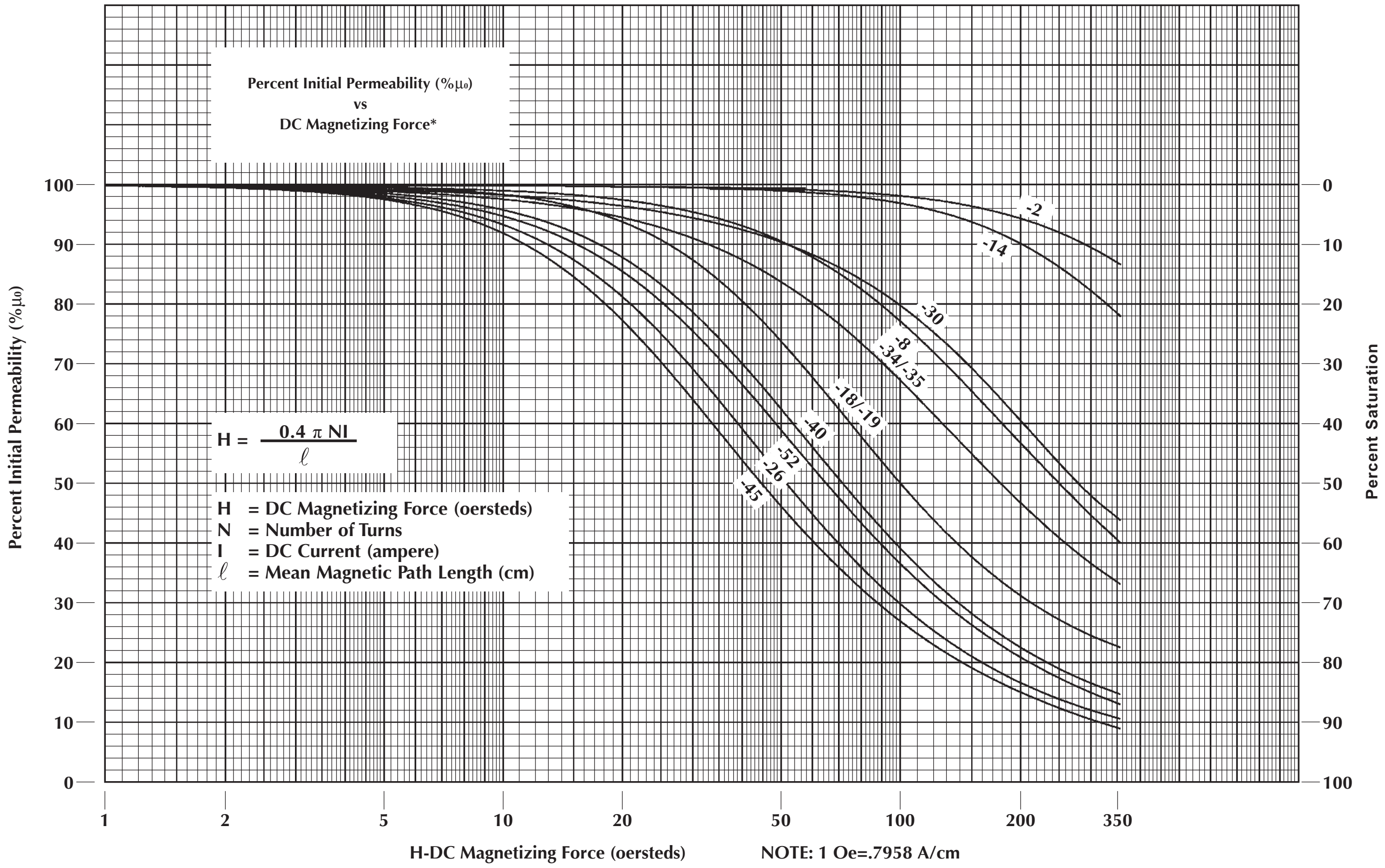
MAGNETIC CHARACTERISTICS





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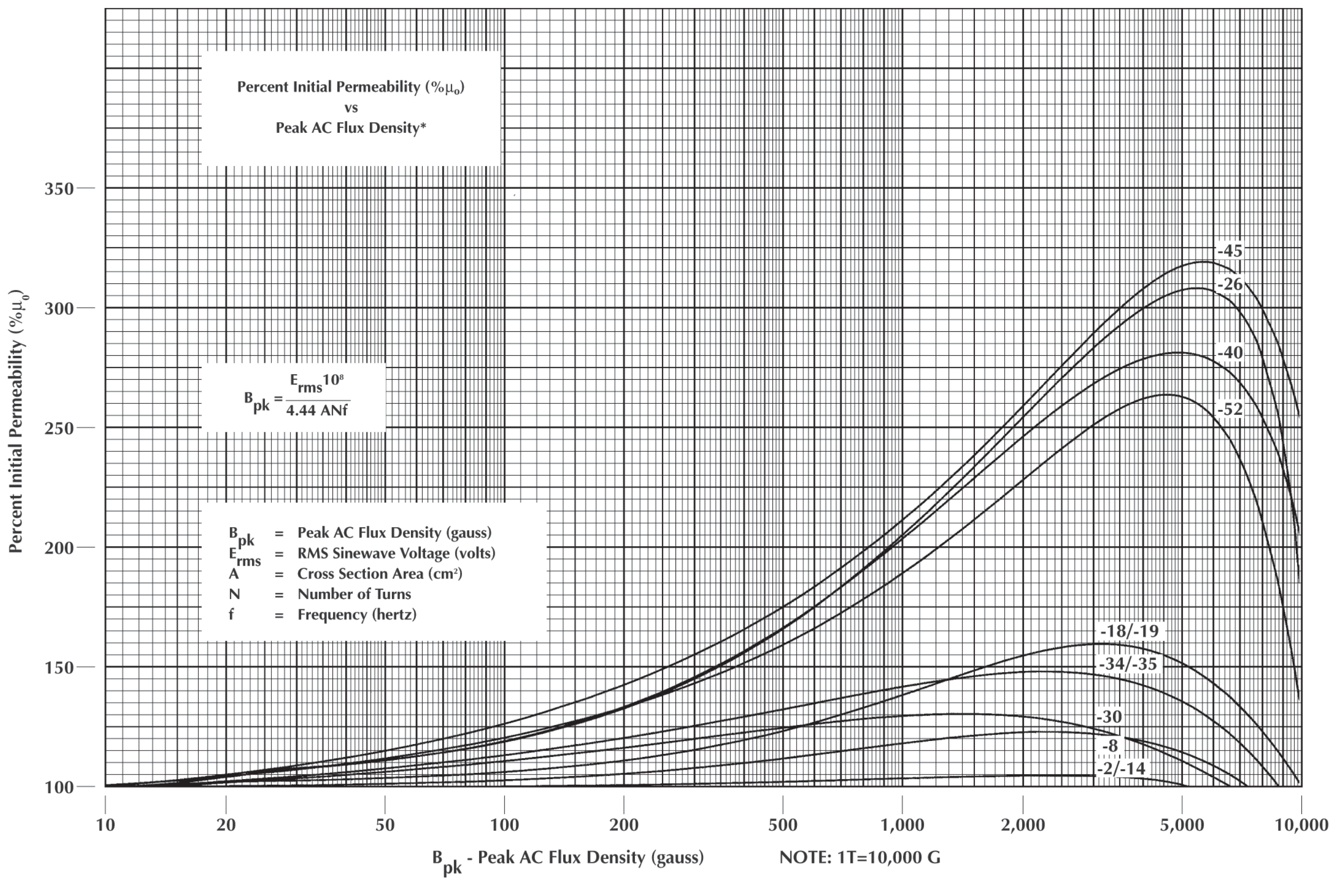
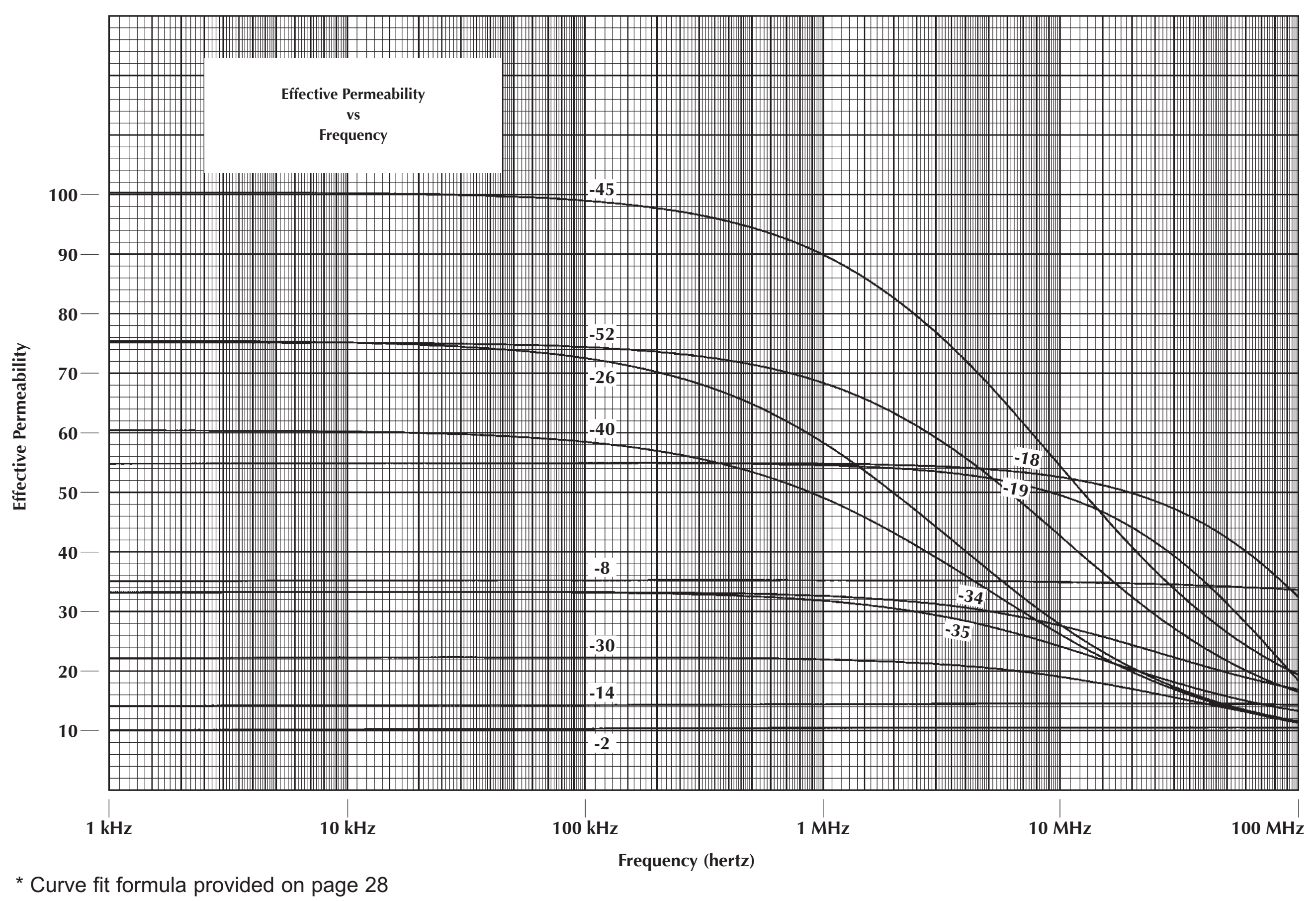
* Curve fit formula provided on page 28





* Curve fit formula provided on page 28

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MAGNETIC CHARACTERISTICS

PERCENT PERMEABILITY vs DC MAGNETIZING FORCE* - See page 26

FORMULA: $\%\mu_0 = ((a+cH+eH^2)/(1+bH+dH^2))^{1/2}$

Where: $\%\mu_0$ = Percentage (ie: 90%=90)
H = DC Magnetizing Force (oersteds)

Material	a	b	c	d	e
-2	10000	6.13×10^{-4}	5.22	3.51×10^{-6}	4.64×10^{-3}
-14	10000	5.61×10^{-4}	5.05	6.86×10^{-6}	5.58×10^{-3}
-8	10090	4.26×10^{-3}	30.9	7.68×10^{-5}	-.0119
-18/-19	9990	8.36×10^{-4}	14.4	3.92×10^{-4}	.0853
-26	10090	5.05×10^{-3}	13.1	1.17×10^{-3}	.0212
-30	10140	4.68×10^{-4}	-30.2	1.45×10^{-5}	.0505
-34/-35	10200	5.12×10^{-3}	7.39	9.62×10^{-5}	.0298
-40	10240	4.32×10^{-3}	12.8	6.26×10^{-4}	.0267
-45	10014	6.07×10^{-3}	45.2	1.79×10^{-3}	-.0578
-52	10240	6.71×10^{-3}	24.7	7.75×10^{-4}	-.0105

PERCENT PERMEABILITY vs PEAK AC FLUX DENSITY* - See page 27

FORMULA: $\%\mu_0 = ((a+cB+eB^2)/(1+bB+dB^2))^{1/2}$

Where: $\%\mu_0$ = Percentage (ie: 90%=90)
B = Peak AC Flux Density (gauss)

Material	a	b	c	d	e
-2/-14	9970	5.77×10^{-4}	7.29	-8.96×10^{-8}	-1.18×10^{-3}
-8	9990	4.52×10^{-4}	11.4	8.82×10^{-9}	-8.29×10^{-4}
-18/-19	10270	1.01×10^{-4}	12.3	2.70×10^{-8}	-8.43×10^{-4}
-26	10600	7.21×10^{-5}	37.8	-7.74×10^{-9}	-3.56×10^{-3}
-40	10480	1.62×10^{-4}	40.8	-6.51×10^{-9}	-3.35×10^{-3}

FORMULA: $\%\mu_0 = a+bB+cB^{1/2}+dB^2$

Where: $\%\mu_0$ = Percentage (ie: 90%=90)
B = Peak AC Flux Density (gauss)

Material	a	b	c	d
-30	93.4	-2.99×10^{-2}	2.08	8.30×10^{-7}
-34/-35	92.6	-2.51×10^{-2}	2.36	1.07×10^{-7}
-45	88.3	6.78×10^{-3}	3.80	-2.72×10^{-6}
-52	92.0	1.34×10^{-2}	2.77	-3.66×10^{-6}

CORE LOSS vs PEAK AC FLUX DENSITY - See page 31-36

FORMULA:
$$CL(mW/cm^3) = \frac{f}{\frac{a}{B^3} + \frac{b}{B^{2.3}} + \frac{c}{B^{1.65}}} + (d\, f^2 B^2)$$

Material	a	b	c	d
-2	4.0×10^{9}	3.0×10^{8}	2.7×10^{6}	8.0×10^{-15}
-8 **	1.9×10^{9}	2.0×10^{8}	9.0×10^{5}	5.0×10^{-15}
-14	4.0×10^{9}	3.0×10^{8}	2.7×10^{6}	1.6×10^{-14}
-18	8.0×10^{8}	1.7×10^{8}	9.0×10^{5}	3.1×10^{-14}
-19	1.9×10^{9}	8.4×10^{7}	2.1×10^{6}	5.0×10^{-14}
-26	1.0×10^{9}	1.1×10^{8}	1.9×10^{6}	1.9×10^{-13}
-30	3.3×10^{8}	2.0×10^{7}	2.0×10^{6}	1.1×10^{-13}
-34	1.1×10^{9}	3.3×10^{7}	2.5×10^{6}	7.7×10^{-14}
-35	3.7×10^{8}	2.2×10^{7}	2.2×10^{6}	1.1×10^{-13}
-40	1.1×10^{9}	3.3×10^{7}	2.5×10^{6}	3.1×10^{-13}
-45	1.2×10^{9}	1.3×10^{8}	2.4×10^{6}	1.2×10^{-13}
-52	1.0×10^{9}	1.1×10^{8}	2.1×10^{6}	6.9×10^{-14}

*** Curve fit formula valid only for ranges shown on graph. ** Revised since last issue.**

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Core losses are a result of an alternating magnetic field in a core material. The loss generated for a given material is a function of operating frequency and total flux swing (ΔB). The core losses are due to hysteresis, eddy current and residual losses in the core material.

Core loss curves for each material are shown on pages 31- 36. This information results from sinewave core loss measurement made on a Clarke-Hesse V-A-W Meter. These curves have a typical tolerance of ±15%. The core loss in milliwatts per cubic centimeter (mW/cm^3) as a function of peak AC flux density in gauss is shown for various frequencies.

A Core Loss Comparison Table is shown on page 1. This table provides a quick comparison of core loss in mW/cm^3 at various frequencies for a given AC flux density for each material. The relative core loss comparison between materials at other AC flux densities will differ according to each materials response to operating AC flux density.

The formula to calculate the peak AC flux density for an alternating signal based on the average voltage per half-cycle in SI units is:

$$B_{pk} = \frac{E_{avg}}{4\,A\,N\,f}$$

Where:	B_{pk}	Peak AC flux density (tesla)
	E_{avg}	Average AC voltage per half-cycle (volts)
	A	Cross-sectional area (m^2)
	N	Number of turns
	f	frequency (hertz)

In cgs units, the following formula is commonly used for a sinewave signal with voltage in rms:

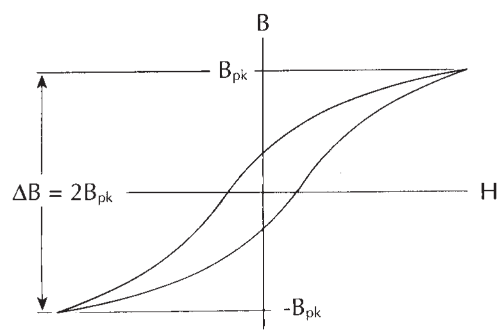
$$B_{pk} = \frac{E_{rms}\,10^8}{4.44\;A\,N\,f}$$

Where:	B_{pk}	Peak AC flux density (gauss)
	E_{rms}	RMS AC voltage (volts)
	A	Cross-sectional area (cm^2)
	N	Number of turns
	f	frequency (hertz)

The factor of 10^8 is due to the B_{pk} conversion from tesla to gauss (1 tesla = 10^4 gauss) and the cross-sectional area (A) conversion from m^2 to cm^2 (m^2 = 10^4 cm^2). The change in constant from 4 to 4.44 is due to the form factor of a sinewave. Since the form factor is equal to the rms value divided by the average value for a half-cycle, the form factor for a sinewave is 1.11 ($\pi/(2\sqrt{2})$). The form factor for a square wave is 1.00.

This formula is useful in determining the peak AC flux density (B_{pk}) to be used with the core loss curves for sinewave applications such as 60 Hz differential-mode line filter inductors, resonant inductors in power supplies, and for the fundamental line frequency signal in power factor correction chokes.

Under this condition, the core experiences a total peak to peak AC flux density swing (DB) that is twice the value of peak AC flux density (B_{pk}) calculated with the above formulas as illustrated:



In inductor applications where the total losses are dominated by core loss rather than copper loss, an overall improvement in performance can be achieved by using a lower permeability core material. This is typically the case in high frequency resonant inductors.

By utilizing a lower permeability core material (such as -2 Material $\mu = 10$), additional turns will be needed to achieve the required inductance. While additional turns will increase the winding losses, it will reduce the operating AC flux density which will result in lower core loss.

It is possible to introduce a discreet air gap into ferrite structures to lower their effective permeability and, thus lower the operating flux density. However, a discreet air gap can cause severe localized gap loss problems. This is particularly true at frequencies above 100 kHz. In many cases the gap loss will exceed the core loss. Since iron powder cores have a distributed air gap, these localized gap losses are essentially eliminated.

To illustrate the core loss benefit of a lower permeability material, consider that an inductor of a given value on -2 Material ($\mu_0 = 10$) will require about 87% more turns than an inductor on -8 Material ($\mu_0 = 35$). The greater number of turns on the -2 Material will result in an AC flux density which is about 53% of the -8 Material flux density. Consequently, the inductor on the -2 Material will exhibit about 1/4 the core loss of the inductor on the -8 Material. In general, the -2 and -14 Material is recommended for resonant inductor applications.

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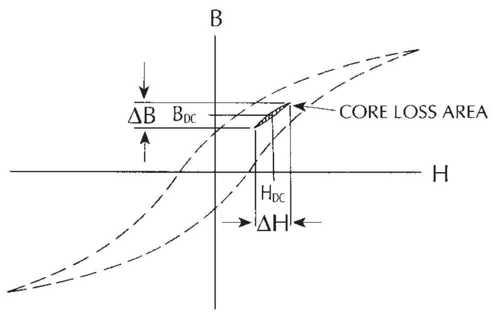
CORE LOSS

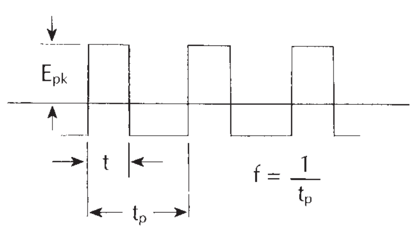
One of the most common applications for iron powder cores in switching power supplies is DC output chokes. In this application, the coil is biased with DC current along with a smaller percentage of ripple current which results from a squarewave voltage. The DC current generates a DC flux density and the squarewave voltage produces an alternating (AC) flux density.

Biasing a magnetic material with DC current will shift the minor alternating BH loop but will not have a noticeable effect on the core loss. It is only the alternating flux density (ΔB) that generates core loss. This condition is illustrated:



Core loss measurements made at the same frequency and total flux density swing (ΔB) produce only slightly higher core loss for squarewaves than for sinewaves.

The following diagram describes a typical squarewave voltage across an inductor in a switching power supply:



Since the volt-seconds (Et) during the "on" and "off" portion of a period must be equal in the steady state, the peak to peak flux density for a squarewave (which is not necessarily symmetric) is described by the following formula in cgs units:

$$\Delta B = \frac{E_{pk}\ t\ 10^8}{A\ N}$$

Where: ΔB — Peak to Peak flux density (gauss)
E_{pk} — Peak voltage across coil during "t" (volts)
t — Time of applied voltage (seconds)
A — Cross-sectional area (cm^2)
N — Number of turns

Another representation of this formula which can also be useful for these applications in cgs units is:

$$\Delta B = \frac{L\ \Delta I\ 10^8}{A\ N}$$

Where: ΔB — Peak to Peak flux density (gauss)
L — Inductance (Henries)
ΔI — Peak to Peak ripple current (amps)
A — Cross-sectional area (cm^2)
N — Number of turns

In unipolar applications such as flybacks, the preceding formulas which describe the total peak to peak flux density need to be used to verify operation within the maximum flux density limit of the core material to avoid magnetic saturation.

However, since it is industry practice to show core loss as a function of peak AC flux density with symmetrical operation about zero, the core loss curves provided assume $B_{pk} = \Delta B/2$. Therefore, core loss is determined from the graphs by using one-half of the peak to peak flux density at the frequency of the total period where $f = 1/t_p$.

The following formulas should be used to calculate the value of peak AC flux density to be used with the core loss graphs on pages 31-36 to determine the high frequency core loss in iron powder cores for a variety of DC biased inductor applications:

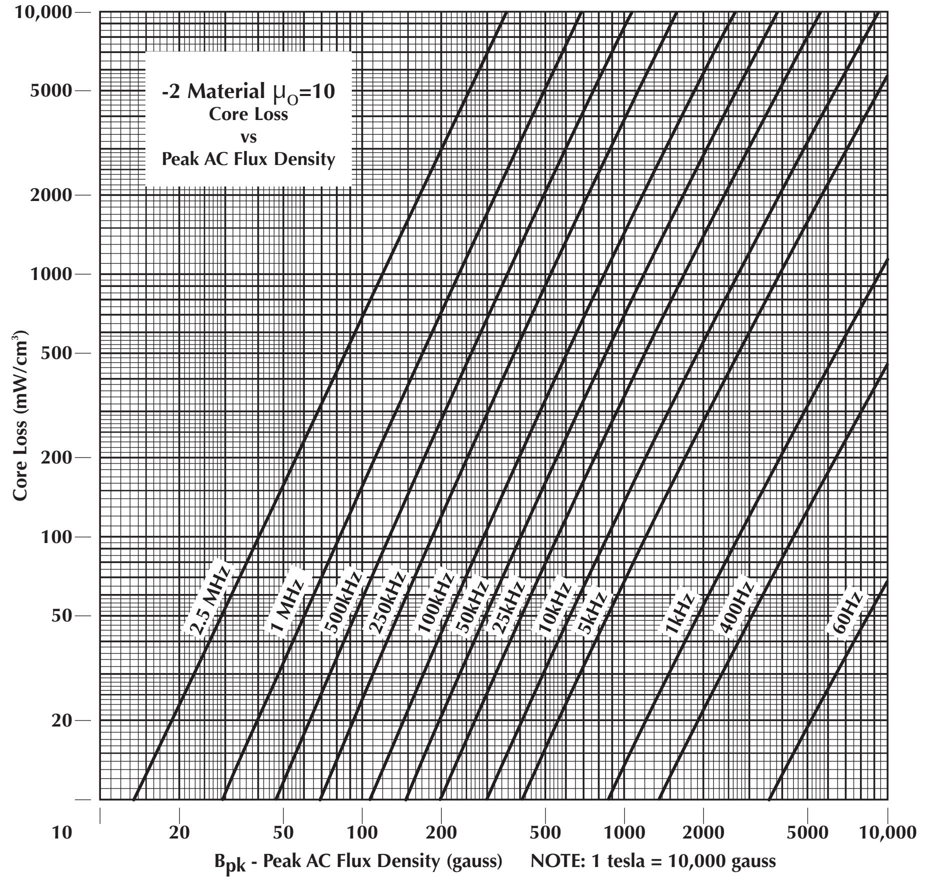
In cgs units:

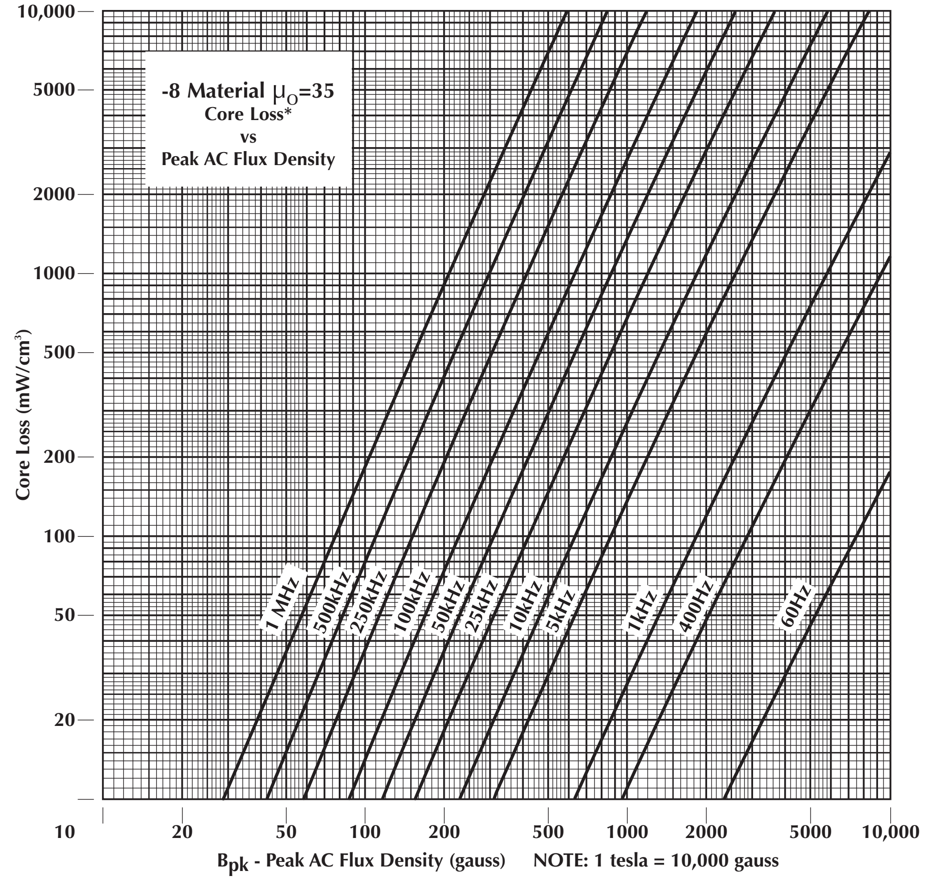
$$B_{pk} = \frac{E_{pk}\ t\ 10^8}{2\ A\ N} = \frac{L\ \Delta I\ 10^8}{2\ A\ N}$$

Where: B_{pk} — Peak AC flux density (gauss)
E_{pk} — Peak voltage across coil during "t" (volts)
t — Time of applied voltage (seconds)
L — Inductance (Henries)
ΔI — Peak to peak ripple current (amps)
A — Cross-sectional area (cm^2)
N — Number of turns

Inductors in active power factor correction boost topologies do not have the simple steady state waveform presented before. Rather, the high frequency signal (typically 100 kHz) is such that both the peak voltage across the inductor (E) and the "on" time (t) are constantly changing throughout the period of the fundamental line frequency (50 or 60 Hz). The core loss in this case will be the time-averaged core loss of the individual pulses for the period of the line frequency.

Please refer to pages 58 and 59 for information on the interpretation of core loss in active PFC inductors.





* Revised since last issue.

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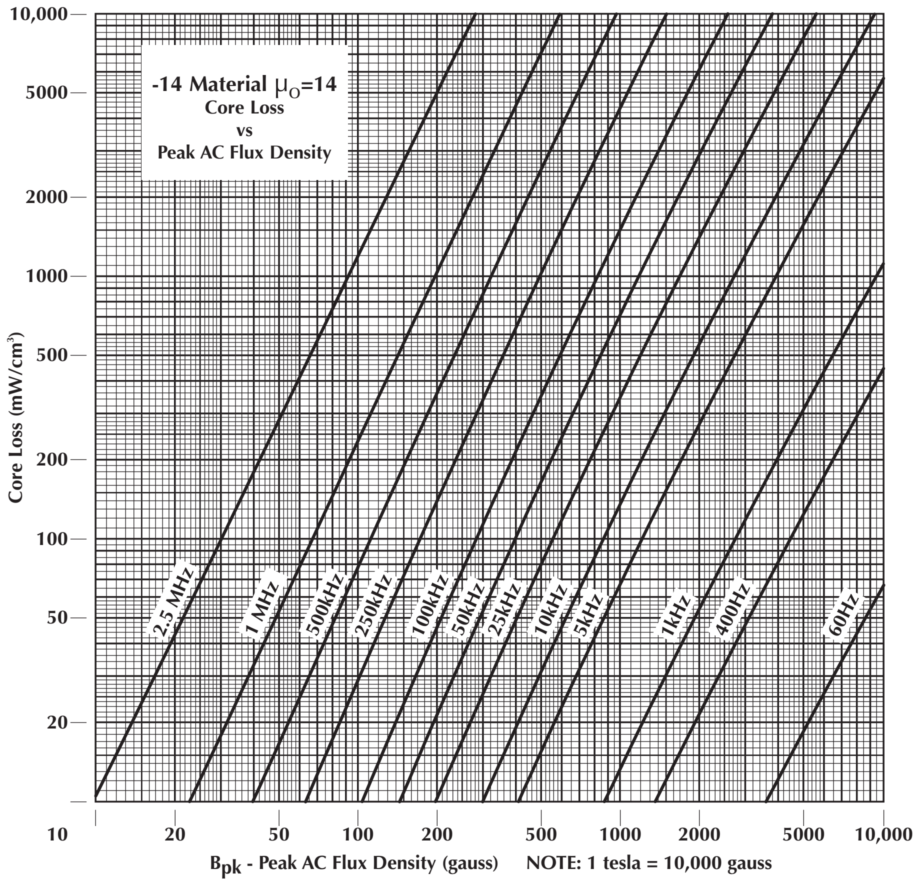
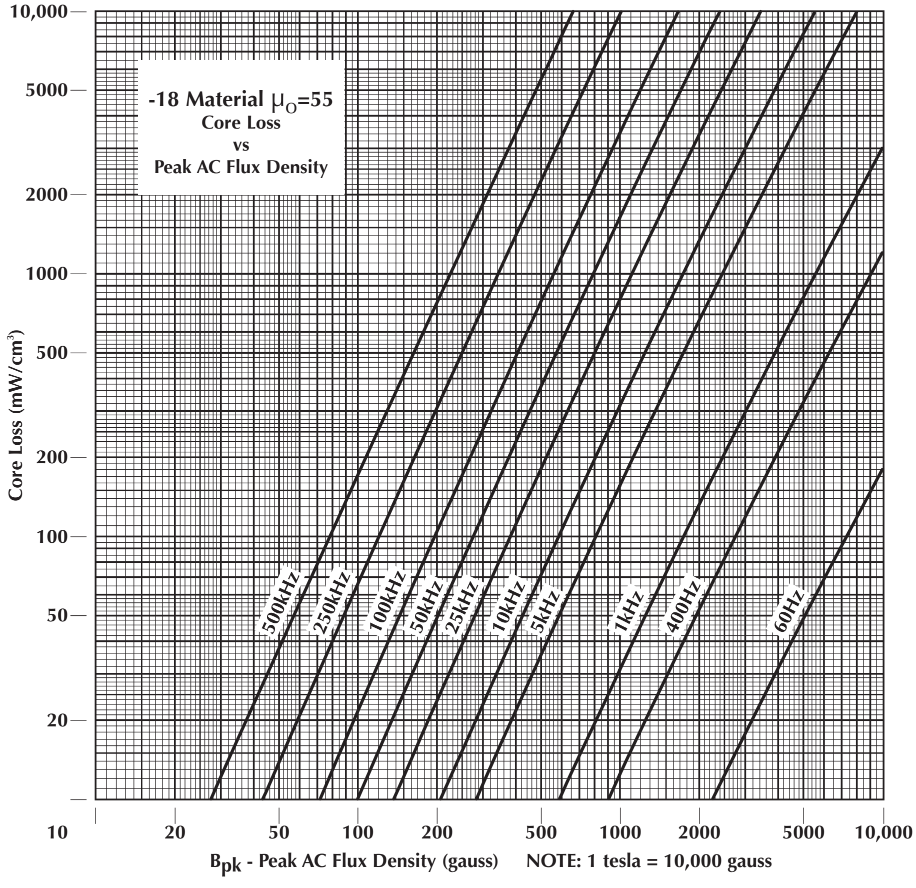
CORE LOSS





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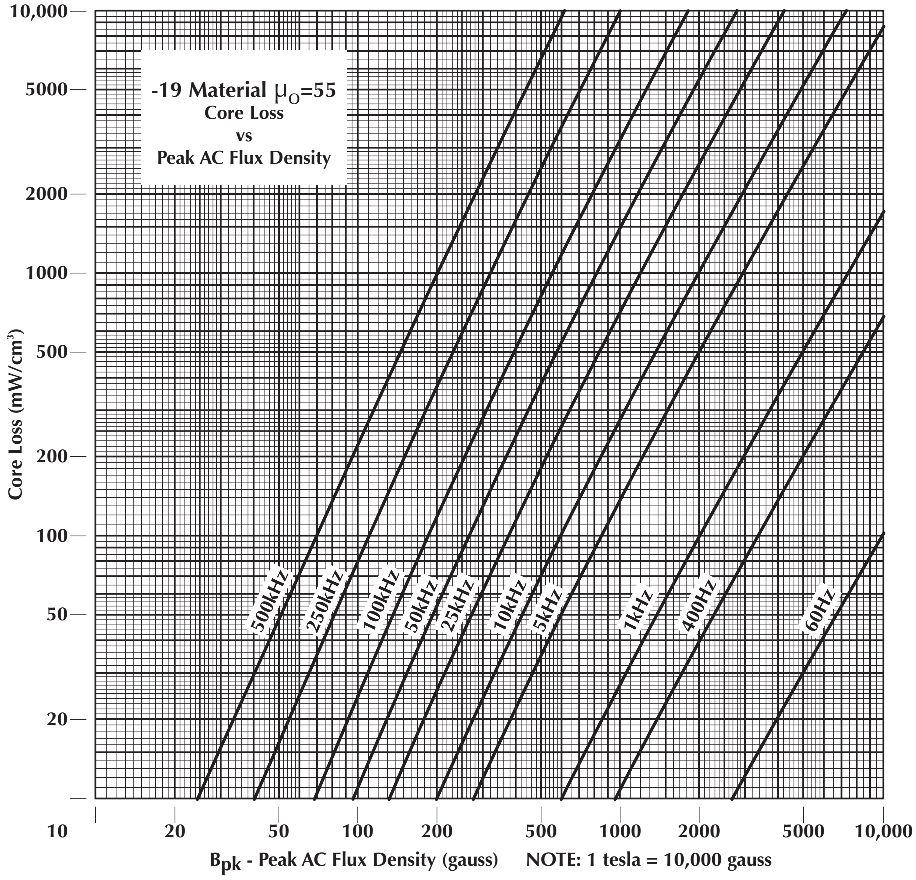

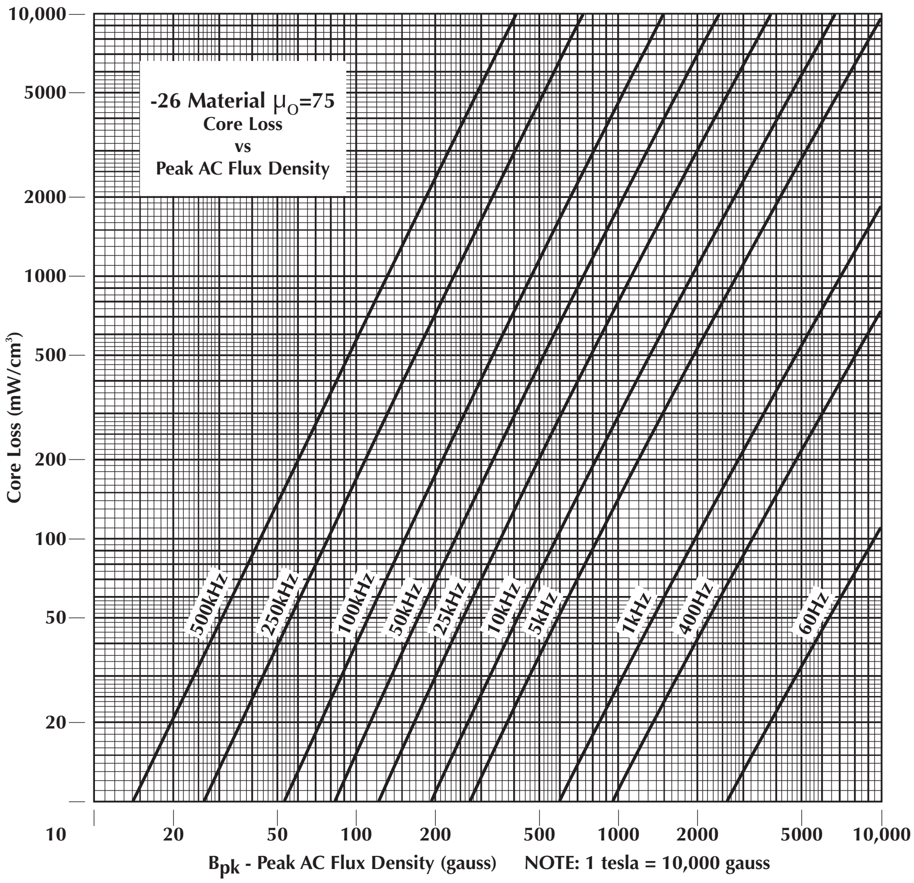

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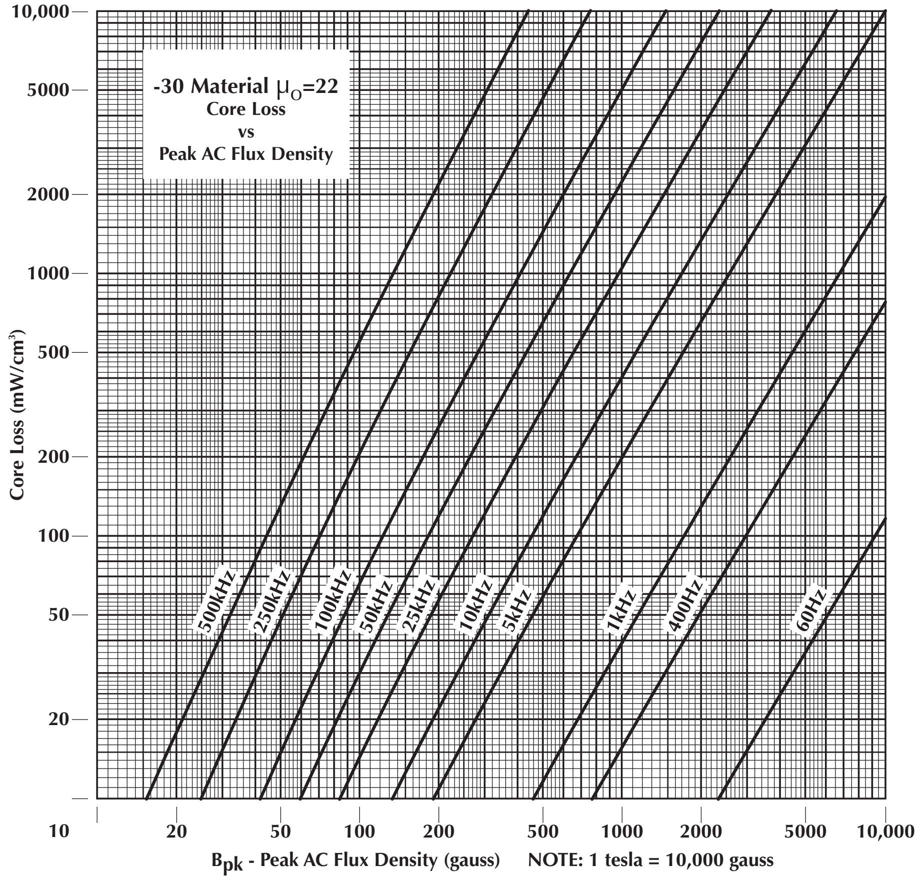

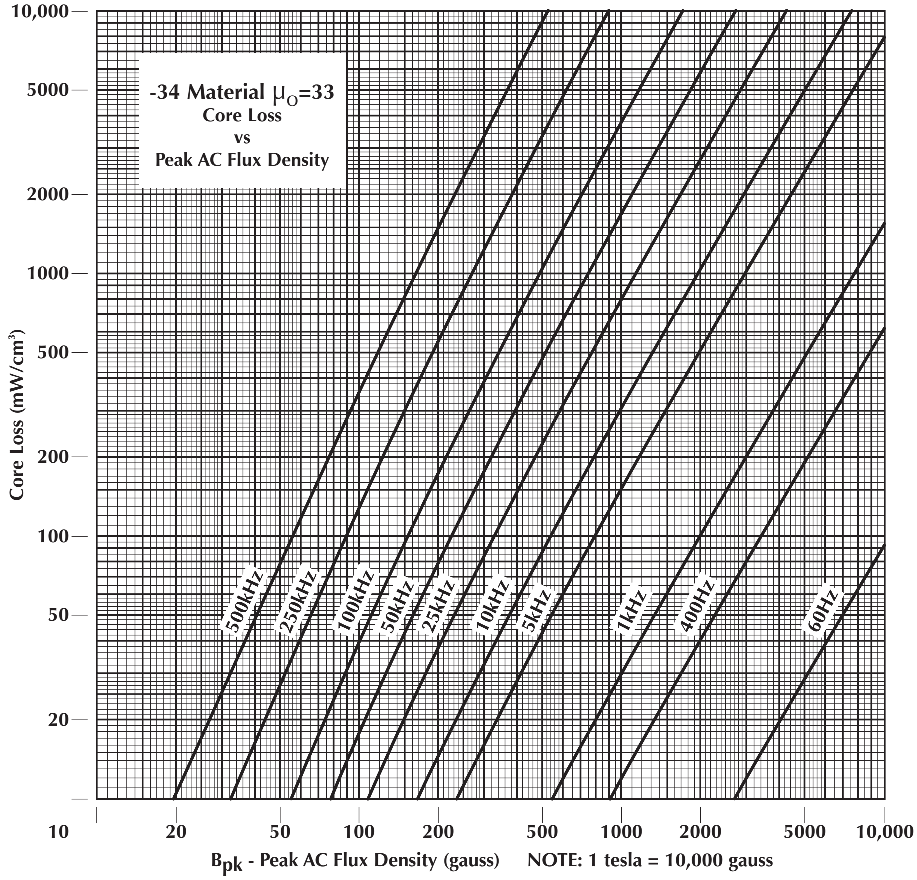

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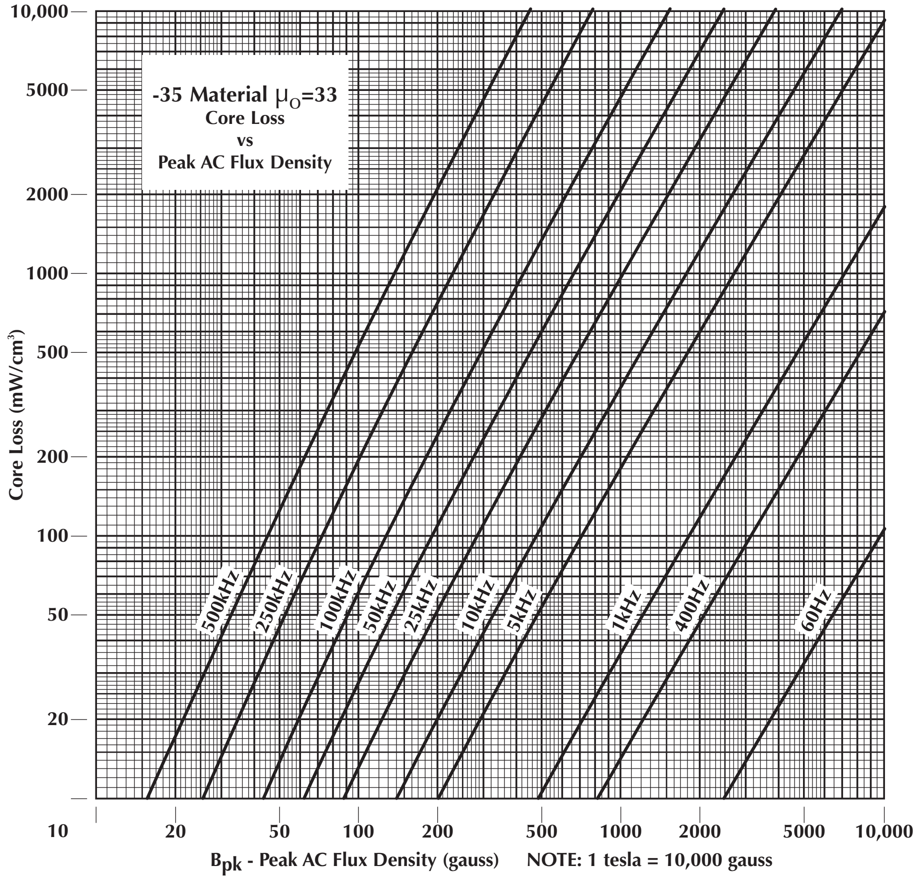

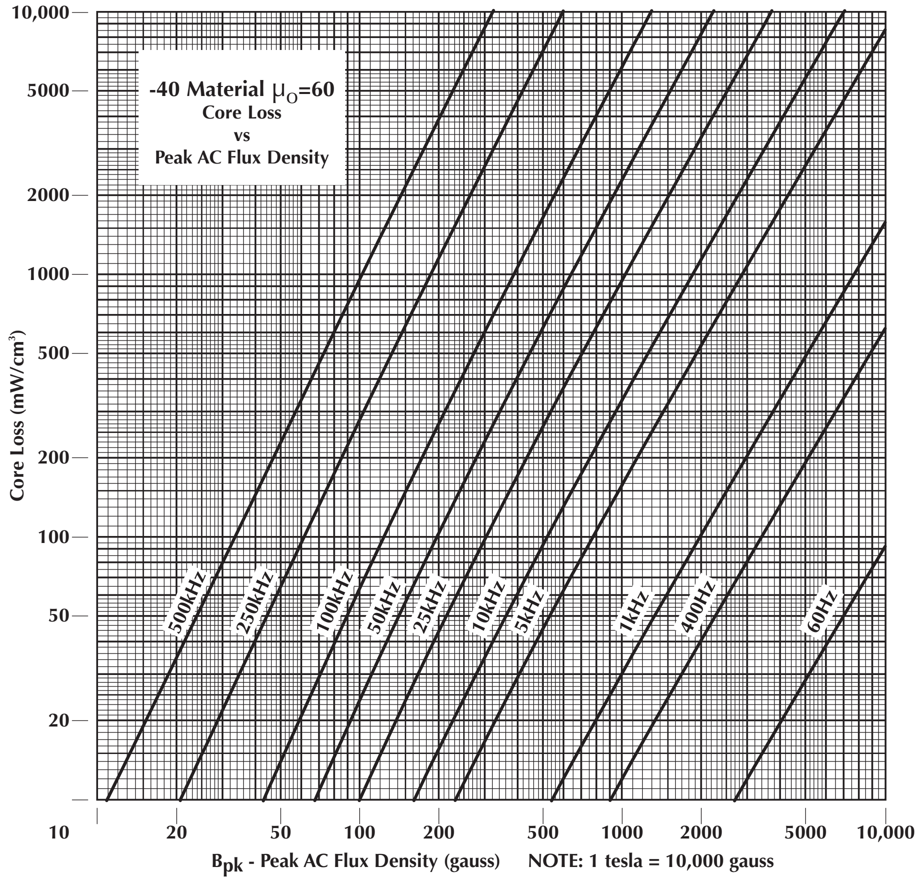

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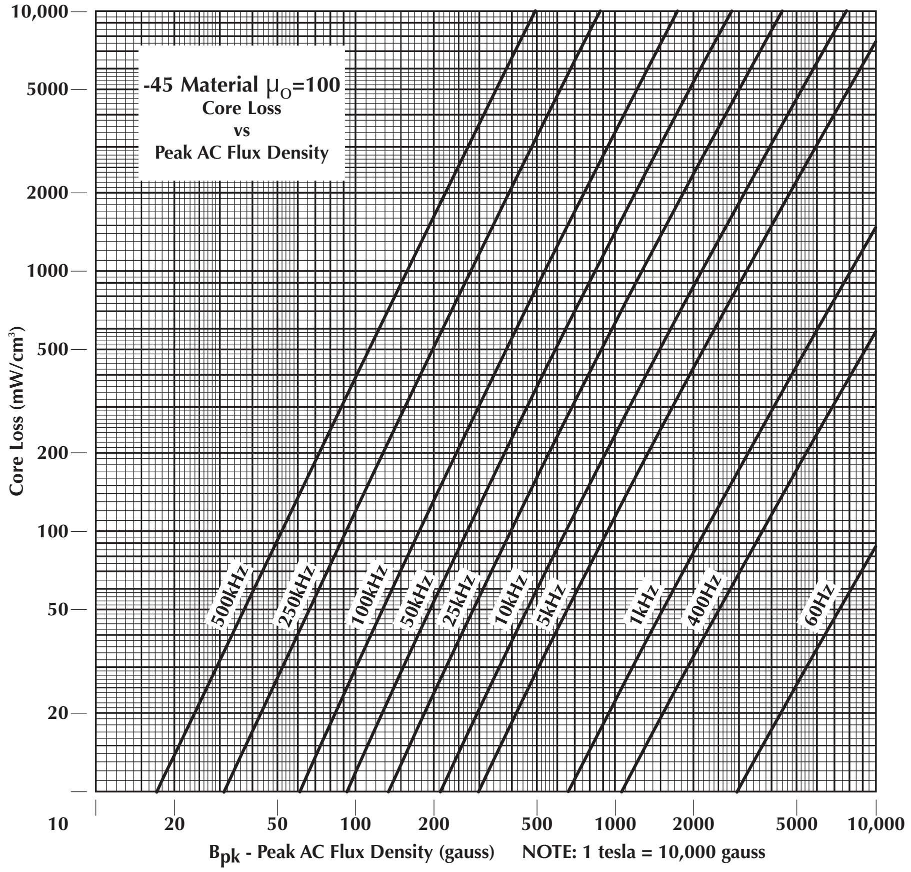

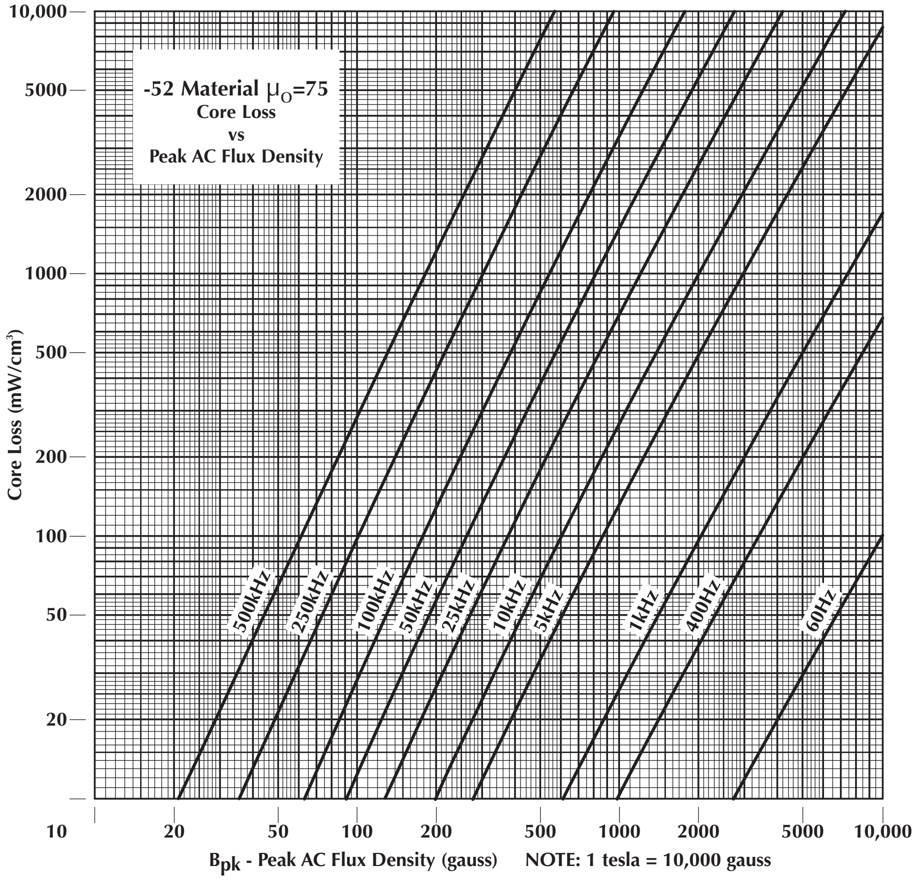

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IRON POWDER CORE INDUCTOR DESIGN SOFTWARE

Micrometals Inductor Design Software is a flexible user-friendly tool designed to supplement this catalog in the selection of iron powder cores for a variety of power conversion and line filter applications. The software is a DOS based program with a file size of 320 kB and is available at no charge. Copies of the disk can be obtained from the factory or through any of our sales representatives. The software can also be down loaded from the Micrometals website at www.micrometals.com.

The main menu for the YEAR 2000 revision contains the following selections:

1) DC Biased Inductors Design where the inductor must meet a given inductance at a DC current level with ripple conditions defined by voltage and frequency.

2) Design of Controlled Swing inductors where the inductance does not exceed a maximum value at reduced current, but is otherwise similar to 1.)

3) Design of Wide Swing inductors where the inductance at low current is typically 5 to 20 times higher than the inductance at maximum DC current. This application utilizes a ferrite/iron powder composite core as described on page 14

4) Design of Active Power Factor Boost or buck inductors, commonly referred to as PFC chokes.

5) Design of Power Line Frequency Inductors for differential-mode filtering using toroidal cores.

6) Design of a Resonant Converter Inductor where the current is sinusoidal with no DC bias.

7) Analyze a design of an inductor based on user defined parameters.

8) Display Micrometals Catalog

9) Wire Table

The design portion of the software accepts typical inputs such as required inductance, dc resistance, dc bias current, peak voltage, output voltage, and frequency. A single-layer or full winding can be specified. The user can select the preferred core geometry (i.e., Toroid, E-Core or Ferrite/Iron Powder Composite) and select specific core materials or all materials.

There are pre-set Design Constants and Limits which can be changed by the user. These parameters and their pre-set values follow:

Measurement Units System	Mixed English	
Wire Gage Standard	American AWG	
Ambient Temperature	25	°C
Maximum Temperature Rise	40	C°
Minimum Copper Density	150	cir-mils/Amp
Maximum Window Fill Factor	40	percent
Minimum % Perm Under DC Bias	40	percent
Wire Resistivity Adjust Factor	1.000	dimensionless
Temp Rise Factor	1.000	C° mW/sq-cm
Temp Rise Characteristic Exponent	0.833	dimensionless
Lead Length Allowance	2.5	inches each

The program will automatically calculate the smallest core size possible that will meet the specified needs and will display; 1) Micrometals Part Number, 2) Approximate unit price, 3) Core A_L Value, 4) Required Number of Turns, 5) Wire Size, 6) Percent Window Fill, 7) DC Winding Resistance, 8) DC Magnetizing Force, 9) Percent Initial Permeability, 10) Core Loss, 11) Copper Loss, and 12) Temperature Rise. The wound dimensions and weight of the copper wire can also be displayed.

The software allows the design engineer to quickly work up multiple design solutions based on user specified electrical requirements and be easily printed for hard copies. The use of pop-up menus and the ability to scroll backwards through the design solutions greatly enhances this revision.

An important new feature of the YEAR 2000 revision is that predicted changes in core temperature versus time and temperature can be graphically displayed for the designs. This feature will allow the design engineer to see if the design is capable of meeting a minimum life expectancy. The graph will display projected core temperature change out 100,000 hours.

The following are definitions of the units utilized by the design software:

Unit	Description	Defined
A_L	Inductance Rating	nH/N^2
Price	US Dollars	Approx.Value*
RDC	DC Resistance	ohms
HDC	Magnetizing Force	oersteds
P FE	Core Loss	watts
P CU	Copper Loss	watts
T Rise	Temperature Rise	celsius degrees

*Approximate value at 5,000 piece quantity

Please contact the factory for technical support. Micrometals will gladly provide sample cores to assist in your evaluation.

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CORE LOSS

CORE LOSS INCREASE DUE TO THERMAL AGING

The following discussion and examples illustrate the phenomenon of thermal aging and detail the variables and conditions that effect a change in core loss characteristics. All iron powder cores, regardless of the manufacturer, are susceptible to permanent increases in core loss when exposed to elevated temperatures for extended periods of time. It is important for the design engineer to understand the conditions under which thermal aging can occur and incorporate this knowledge into their standard design process.

Thermal aging is an irreversible increase in core loss as a result of prolonged exposure to elevated temperatures. The extent of these changes and realized effect on the wound core are a function of the following variables; time, ambient temperature and air flow, core volume and shape, operating frequency, peak ac flux density, material type and core manufacturer. Eddy current loss will be the dominant loss at higher frequencies while hysteresis loss will be the dominate loss at lower frequencies. The contribution of each form of loss to the total is also affected by the operating flux density. It is the eddy current portion of the core loss which is affected by high temperature thermal aging.

The first example will illustrate what happens in a design that is dominated by core loss and uses an undersized core. This design utilizes a core that can not safely dissipate the high level of core loss even with the benefit of forced air.

The first design example is for a buck inductor operating at 80 kHz. The parameters are as follows:

L = 11.5 µH
Idc = 18 A
E pk = 45 V
E dc = 12.3 V

The maximum ambient temperature is 60°C with forced air cooling supplied by a variable speed fan that provides less air flow at lower power levels.

The core selected is part number T106-52 wound with 14 turns of AWG-14 resulting in 1.72 W of copper loss. The peak AC flux density is 670 G at 80 kHz produces a core loss of 4.9 W. The combined loss is 6.62 W which calculates to a temperature rise of approximately 83C°in free standing air. Since the maximum ambient temperature specified for this part is 60°C the inductor can easily reach 140°C without the benefit of forced air. It should be noted that the core loss tolerances for Micrometals cores are +/-15%. Under worst case core loss conditions, the 4.9 W nominal can be 5.64 W resulting in a total loss of 7.36 W for a temperature rise of 95C°in free standing air. These temperatures are much too hot for a core operating under these conditions where eddy current losses are a significant portion of the total loss. The T106 size core can safely dissipate a total of 2.59 W for a 40C°temperature rise.

Caution, a warning flag should go up on a design that is *core loss dominated* and depends on the use of air flow to reduce the temperature particularly if it uses a variable speed fan. While the copper loss will decrease at lower power levels, this is generally not the case with core loss. Variable speed fans should not be used with core loss dominated designs. *It is much easier to remove heat from a copper loss dominated design than a core loss dominated design*. The copper winding radiates the heat while the core material has a thermal impedance barrier that must first be overcome. Additionally, the inductor can be several degrees hotter on the inside of the core and in the "shadow of the air flow".

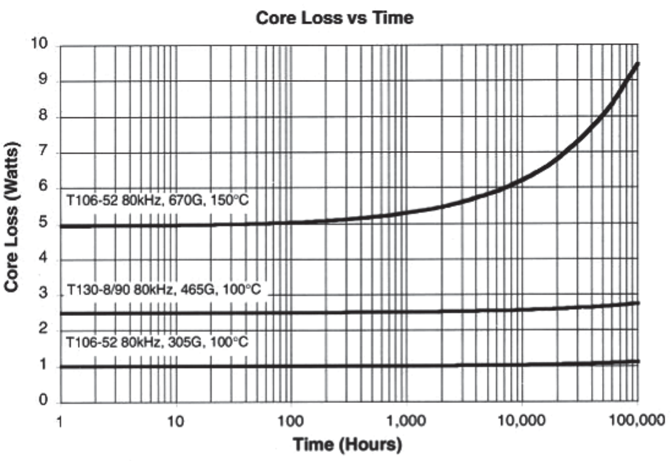

Figure 1

The upper curve in Figure 1 illustrates how quickly the projected core loss increases due to the excessive operating temperature. It should be obvious the surface area of this design is much too small to safely dissipate the excessive core loss in spite air flow. Pages 64 and 65 show the "Total Power Dissipation (W) Vs Temperature Rise" for various sized Micrometals cores. These tables are useful to quickly determine if the design is capable of meeting a 40C°or less temperature rise.

The middle curve in Figure 1 illustrates the smallest physical core size that meets the design requirements and has a temperature rise of less than 40C°. This core is part number T130-8/90 wound with 19 turns of AWG-10 for a copper loss of about 1.0 W. The peak AC flux density has been reduced to 465 G at 80 kHz decreasing the core loss to 2.5 W. The graph predicts this design will safely operate at 100°C total temperature well past 100,000 hours.

The lower curve of Figure 1 shows part number T106-52 used under similar conditions to the first design except now the dc output voltage is 5 V instead of 12.3 V. With 14 turns of AWG-12 wire, the peak AC flux density has decreased to 305 G and core loss to 1.0 W. The combined core and copper losses are 2.04 W for a temperature rise of 33C°. This design will safely operate at 100°C total temperature for more than 100,000 hours.

The next design examples will illustrate differences using a much larger core size, operating at two differing frequencies and peak AC flux densities.

The first design is operating at 60Hz, 10 kG on Micrometals part number T300-26D. The calculated core loss is about 7.35 W and assuming a copper loss of 7.35 W, the combined loss of 14.7 W results in a 33C° temperature rise. The lower curve in Figure 2 predicts that the core loss does not change even after 100,000 hours at 125°C. Almost all of the core loss at this frequency is hysteresis loss and is unaffected at this temperature.

The upper curve in Figure 2 shows how quickly the core loss increases in a design operating at 40 kHz with a peak AC flux density of 283 G. While the total core loss of 7.35 W is the same as the 60 Hz example, the eddy current losses are now dominant and increase with constant exposure to 125°C. Assuming the copper loss is 7.35 W, the total loss of this design is 14.7 W resulting in a temperature rise of 33C°at time zero. After 20,000 hours the core loss has increased to 9.5 W and the temperature rise now reaches 37C°. After 100,000 hours at 125°C, the core loss has increased to 12.5 W, pushing the temperature rise to 42C°. This design example is not an extreme case but illustrates how the temperature rise of the inductor continues to increase as a function of time and temperature.

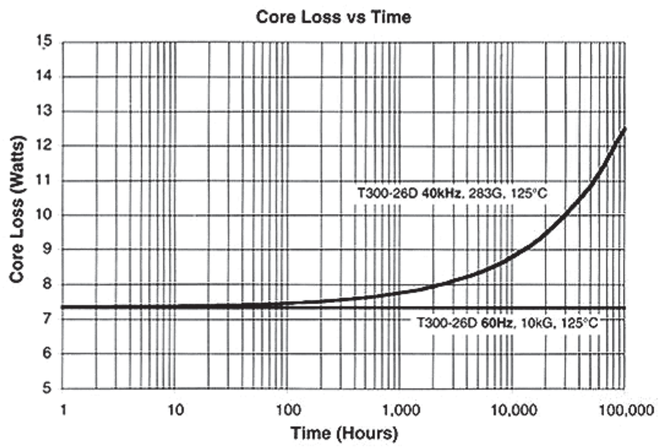

Figure 2

Another popular application for iron powder cores is power factor correction boost chokes. This can be a very demanding application where core loss calculation is more complex and often misunderstood. This can lead to poor designs that will have reliability problems. For a detailed discussion of proper core loss analysis for PFC boost chokes refer to page 58 of this catalog. Also, the latest version of Micrometals design software includes a PFC core loss application.

	Solution #1	Solution #2	Solution #3
Part Number	E168-52	E168-52	E168-2
A_L (nH/N^2)	179	179	44
Turns	45	90	76
AWG#	14	17	16
Bpk @ 100 kHz (G)	389	195	230
Core Loss (mW/cm^3)	495.9	120.0	61.5
Core Volume (cm^3)	18.5	18.5	18.5
Core Loss (mW)	9,174	2,220	1,137
Copper Loss (mW)	866	3,480	2,324
Total Loss (mW)	10,040	5,700	3,461
Wound Surface Area (cm^2)	66.7	66.7	66.7
Maximum Size (in)	1.7 x 1.7	1.7 x 1.7	1.7 x 1.7
T (C°)	65	41	27
Approx. Core Cost (per piece)	$0.23	$0.23	$0.55
Thermal Life (Hours)	<12,000	~1,000,000	>10,000,000

Table 1

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CORE LOSS

The third design example is a PFC boost choke operating at 100 kHz with the following requirements:
Lmin = 250 µH
Idc = 7 A
Epk In = 120V
Edc Out = 400V

Referring to Table 1, you can see that design Solution #1 is a design that is dominated by 9.17 watts of core loss with only 0.87 watts of copper loss. This results in a temperature rise of 65C°. Figure 3 indicates that with an ambient of 55°C, this part will have thermal runaway in less than 2 years.

Solution #2 demonstrates that with the same core, by simply increasing the number of turns with the required smaller wire size, the core and copper losses will become more balanced. This results in improved efficiency (saving 4.3 watts), a lower operating temperature (ΔT=41C°), and a dramatic improvement in thermal life (almost 2 orders of magnitude). While it may seem obvious that solution #1 is a poor design, this is a fairly common mistake.

If the higher inductance produced by adding turns in solution #2 is unacceptable in the circuit, the core and copper losses can also be better balance by selecting a lower permeability material. Solution #3 illustrates how the Micrometals 10μ_o (-2 Material) performs. This choke will be the most efficient and reliable, but this material type is more expensive than the –52 Material option.

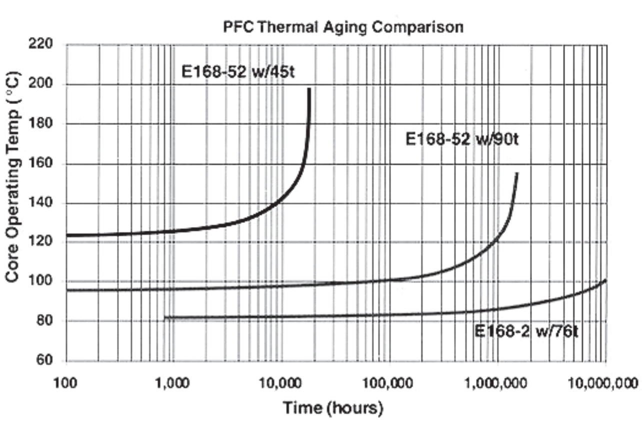

Figure 3

Another important thermal aging consideration is the source of the iron powder cores, in other words, beware of "equivalent" iron powder cores. As demonstrated above, different materials will thermally age at different rates. This is also true with different manufacturers of core materials. In many cases, the term "equivalent core" is solely based on dimensional and permeability characteristics.

Figure 4 illustrates the thermal aging characteristic of Micrometals T90-26 at 75kHz with 633G as well as the same winding on an "equivalent" competitor. The Micrometals core will safely operate for 300,000 hours whereas the competitor will runaway in less than 30,000 hours. Clearly, both cores are thermally aging at different rates.

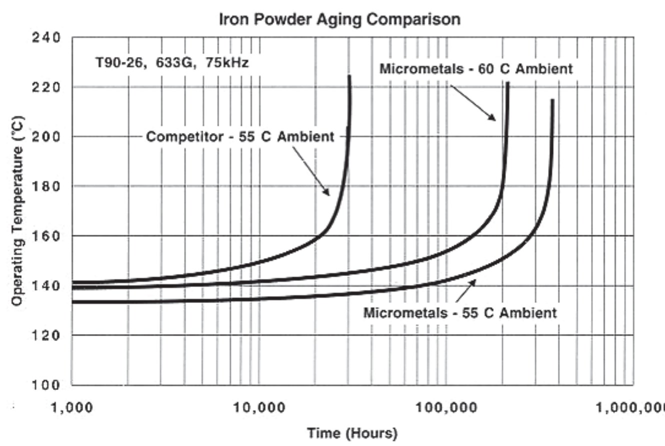

Figure 4

Less obvious is the variation of initial core operating temperatures between the Micrometals and competitor cores. The competitors increased initial core temperature is a result of higher core losses. In another example, the ambient temperature for the Micrometals winding was increased to 60 °C to match the initial core operating temperature of the competitor. Again, the predicted difference in thermal life is dramatic.

As the example above demonstrate, evaluating one manufacturers core and substituting another at a later time can be a critical error. It is also very important to regulate the supply chain and monitor that subsuppliers are not making any unknown core substitutions.

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The design software described on the previous page is an extremely useful tool for selecting Micrometals iron powder cores for DC applications and compliments the energy storage curves provided here.

DC energy storage inductors are an ideal application for Micrometals iron powder cores. In this application the core must support a significant DC current while maintaining an inductance adequate to filter high frequency signals. The amount of energy stored is a function of inductance and current. Specifically, energy storage fo an inductor is described:

$$\text{Energy} = 1/2\ LI^2$$

Microjoules (μJ) — Microhenries (μH) — Amperes (a)

Energy storage is proportional to the flux density squared divided by the effective premeability of the structure.

$$\text{Energy} \sim \frac{B^2}{\mu_{\text{effective}}}$$

The introduction of a discreet air gap significantly lowers the effective permeability of core structures made from ferrites and iron alloys. This increases the energy storage capabilities of the core by allowing additional energy to be stored in the gap.

DC inductors, most commonly, fall into one of 3 basic categories:

1. Those specifically designed to maintain a relatively constant inductance from zero to full-rated load.
2. Those specifically designed to have greater inductance, under minimum load conditions (swing).
3. Those simply requireing a minimum inductance.

Micrometals Energy Storage Curves are presented for a number of core sizes in each material (except -2 Material due to its low permeability) to assist in the design of such inductors. These curves are shown a both in terms of ampere-turns (NI) at the top portion of each page, and percent saturation (100% -% initial permeability) at the bottom portion of each page.

The curves shown on pages 42-51 are based on a peak AC flux density of 10 gauss (1 mT). This will typically represent a ripple current of less than 1%. Under this condition, the only heat generated results from the resistive winding (copper) losses. The energy storage limits for 10 C°, 25 C°, and 40 C° temperature rise (in free-standing air) resulting from winding losses are shown on each graph.

When significantly greater AC or ripple flux density is present, the cores will produce higher inductance due to the AC magnetization characteristics shown at the top of page 27. Under this condition, the high frequency core losses must also be taken into account as described on pages 29 - 36. Refer to pages 56 - 57 for additional information.

The -8 , -18 and -52 Materials should be considered for DC shokes operating above 100kHz due to their lower core loss characteristics at high frequency.

The importance of the swing of the inductor must be determined before the appropriate core material can be selected.

1. The -8, -18, -30, -34 and -35 Materials (or a gapped E Core, see pags 54-55) should be considered if the inductor must maintain a relatively constant inductance from minimum to full-rated current. These materials are able to store high energy with a minimum of staturation.
2. The -26, -40, -45 and -52 materials should be considered if the inductor should “swing” (increase in inductance as current decreases) a moderate amount. These materials have higher permeability and can produce a 2:1 swing (50% saturation point).
3. The -26, -40 and -52 Materials are generally recommended for designs concerned with minimum inductance because they ar the most cost effective.

The temperature rise of the wound unit, aside from saturation, is the primary limiting factor in inductor design. In the case of DC inductors with very low level AC ripple, this temerature rise is a result of copper loss in the winding. (DC flux does not have a noticeable effect on core loss.)

For single-layer windings on toroidal cores, the current handling capability of a wire size as a function of temperature rise is relatively independent of core size. Making use of this, a single-layer winding table has been developed giving current ratings for temperature rises of 0 C°, 25 C°, and 40 C° temperature rise in free-standing air. (page 64)

For full windings (45% toroid inside diameter remaining) a similar table has been developed. (page 65) In the case of full windings, the current handling capability of a given wire size is no longer independent of core size. However, for any particular core size, an ampere-turn rating for a given temperature rise does become a constant. These ampere-turn constants are included in the full windig table.

Refer to page 57 for design examples using the Energy Storage Curves.

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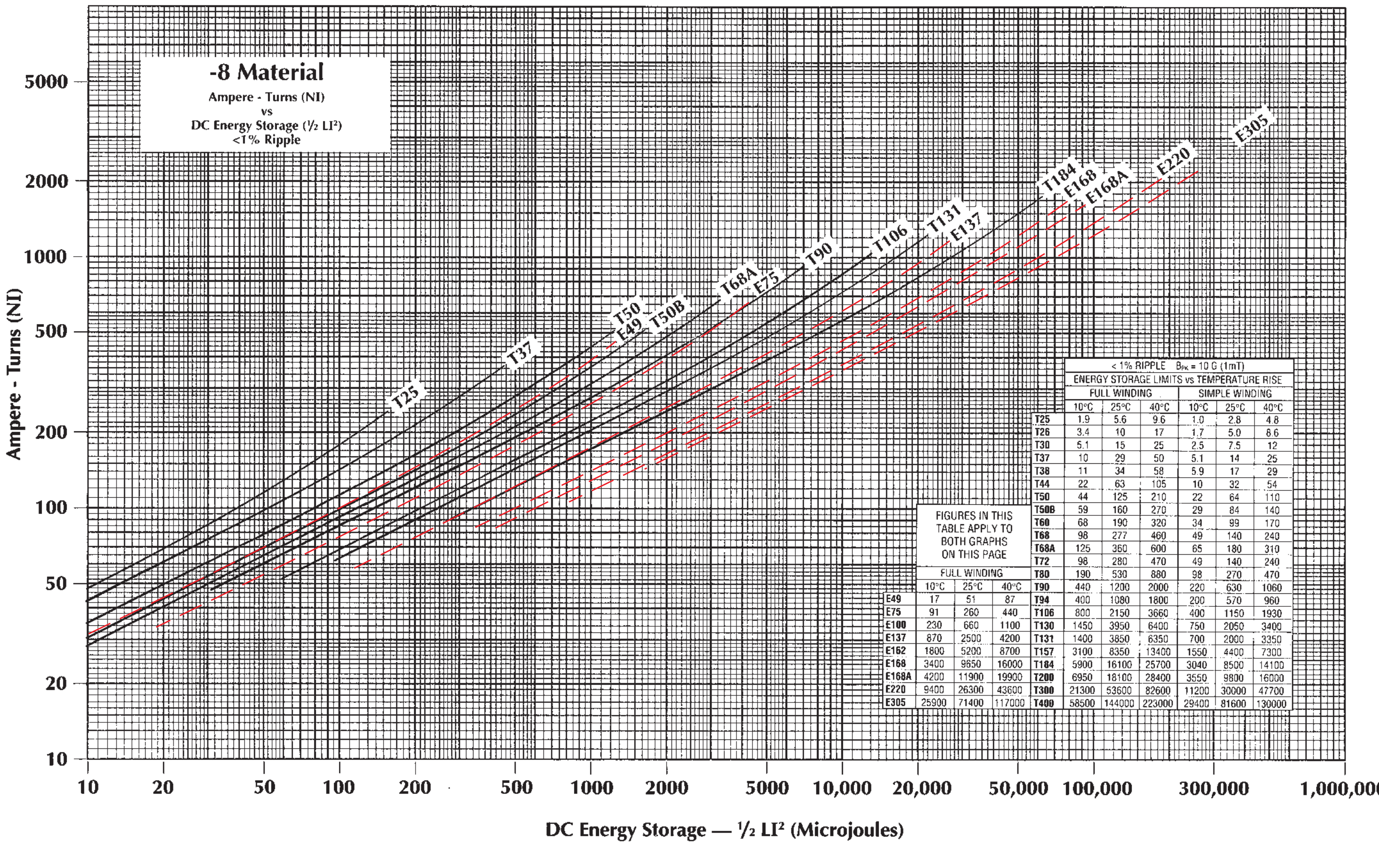


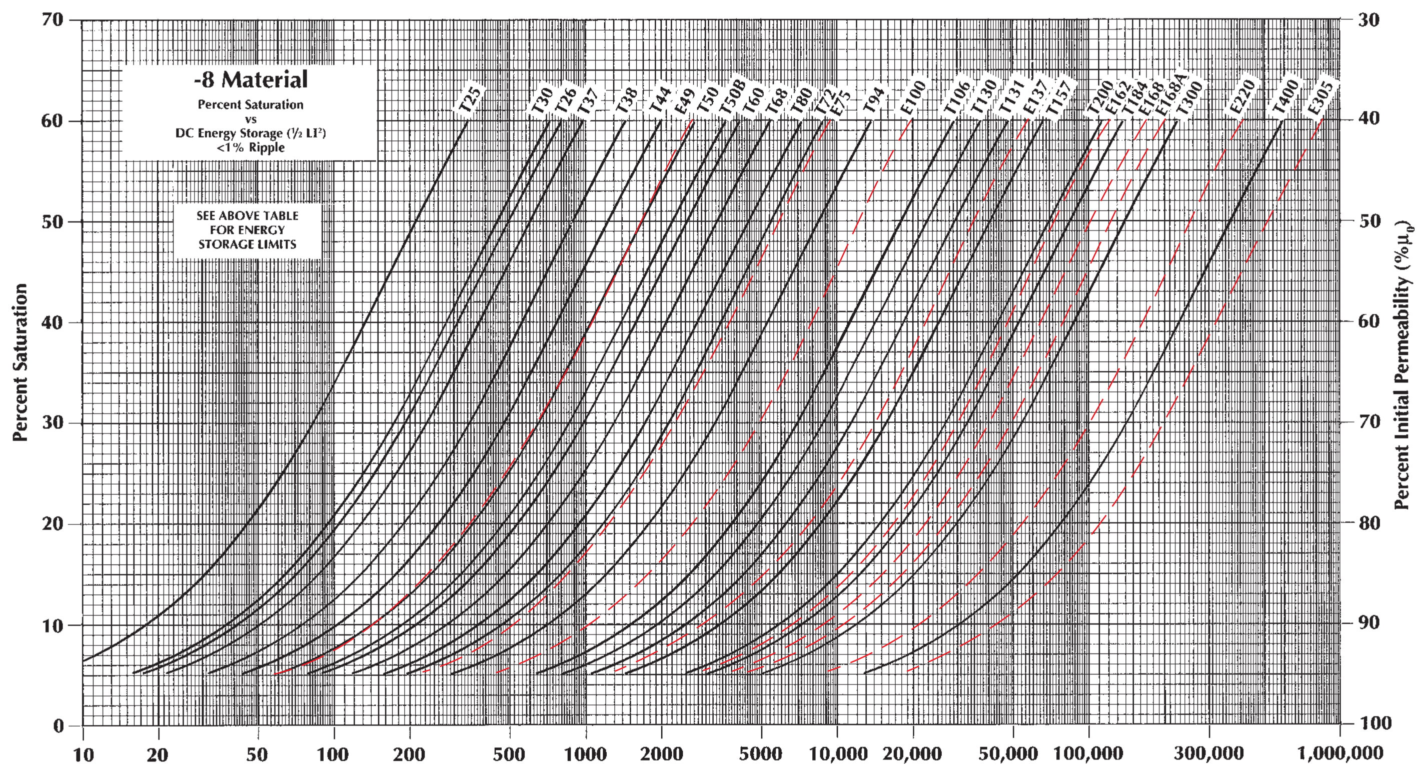
< 1% RIPPLE B_{PK} = 10 G (1mT)
ENERGY STORAGE LIMITS vs TEMPERATURE RISE

	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T25	1.9	5.6	9.6	1.0	2.8	4.8
T26	3.4	10	17	1.7	5.0	8.6
T30	5.1	15	25	2.5	7.5	12
T37	10	29	50	5.1	14	25
T38	11	34	58	5.9	17	29
T44	22	63	105	10	32	54
T50	44	125	210	22	64	110
T50B	59	160	270	29	84	140
T60	68	190	320	34	99	170
T68	98	277	460	49	140	240
T68A	125	360	600	65	180	310
T72	98	280	470	49	140	240
T80	190	530	880	98	270	470
T90	440	1200	2000	220	630	1060
T94	400	1080	1800	200	570	960
T106	800	2150	3660	400	1150	1930
T130	1450	3950	6400	750	2050	3400
T131	1400	3850	6350	700	2000	3350
T157	3100	8350	13400	1550	4400	7300
T184	5900	16100	25700	3040	8500	14100
T200	6950	18100	28400	3550	9800	16000
T300	21300	53600	82600	11200	30000	47700
T400	58500	144000	223000	29400	81600	130000

	FULL WINDING		
	10°C	25°C	40°C
E49	17	51	87
E75	91	260	440
E100	230	660	1100
E137	870	2500	4200
E162	1800	5200	8700
E168	3400	9650	16000
E168A	4200	11900	19900
E220	9400	26300	43600
E305	25900	71400	117000

QUICK REFERENCE A_L VALUES FOR -8 MATERIAL

PART NO.	T25	T26	T30	T37	T38	T44	T50	T50B	T60	T68	T72	T80	T94	T106	T130	T131	T157	T184	T200	T300
A_L VALUE	10.0	24.0	14.0	12.0	20.0	18.0	17.5	23.0	19.0	19.5	36.0	18.0	25.0	45.0	35.0	52.5	42.0	72.0	42.5	37.0
PART NO.	T400		E49	E75	E100	E137	E162	E168	E168A	E220	E305									
A_L VALUE	60.0		20.5	33.5	48.0	67.0	105	97.0	116	143	156									



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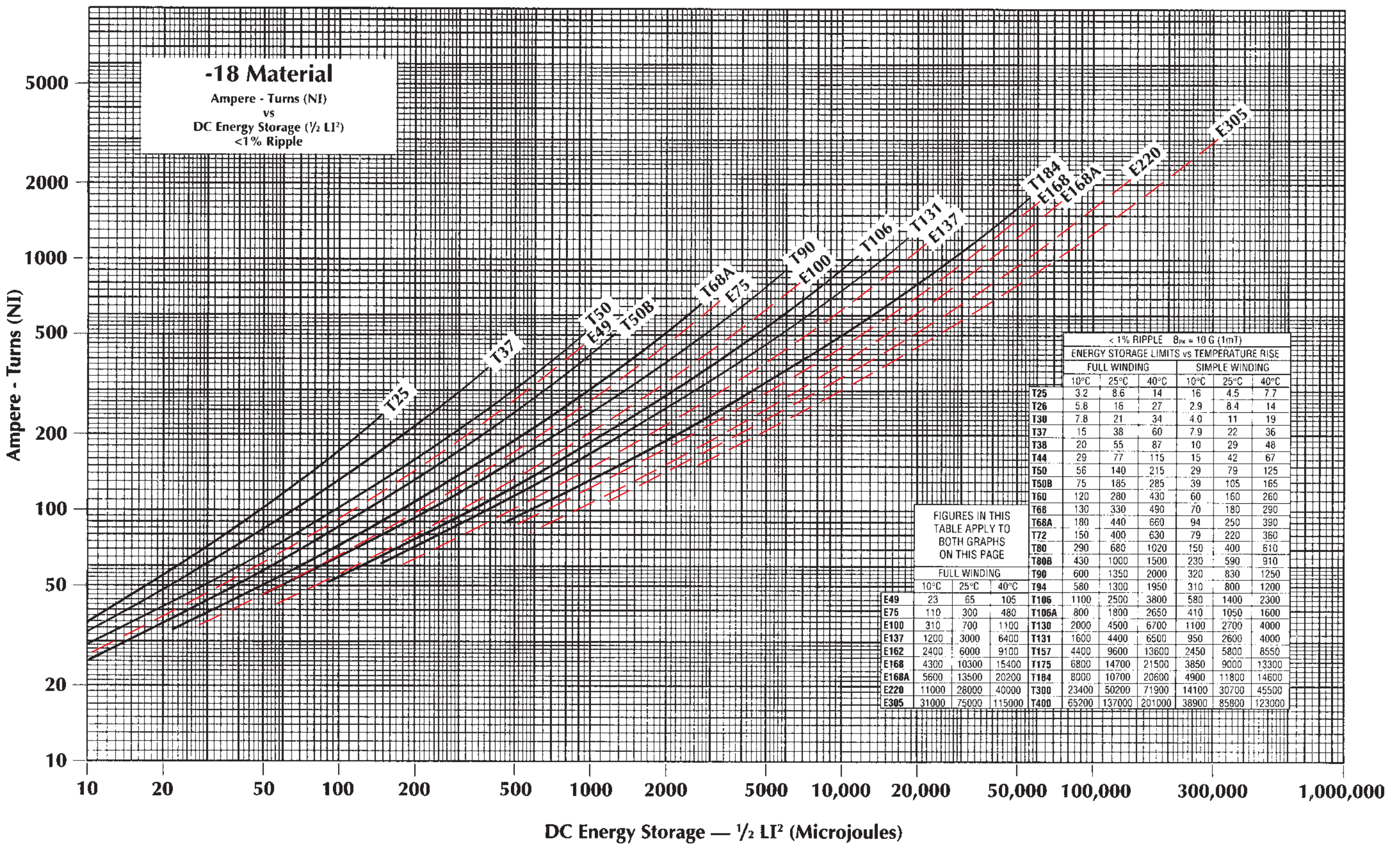
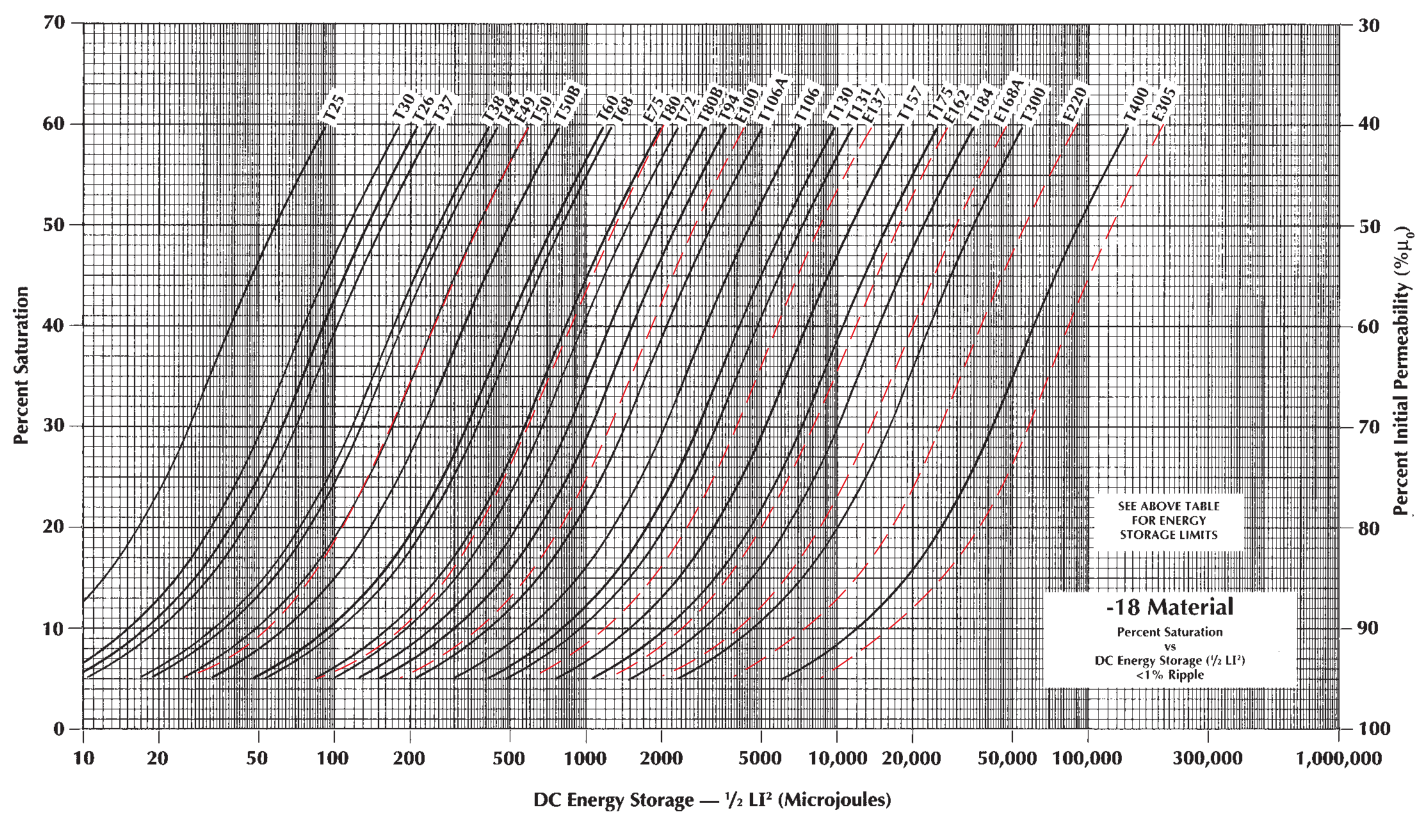


	< 1% RIPPLE B_{PK} = 10 G (1mT)					
	ENERGY STORAGE LIMITS vs TEMPERATURE RISE					
	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T25	3.2	8.6	14	16	4.5	7.7
T26	5.8	16	27	2.9	8.4	14
T30	7.8	21	34	4.0	11	19
T37	15	38	60	7.9	22	36
T38	20	55	87	10	29	48
T44	29	77	115	15	42	67
T50	56	140	215	29	79	125
T50B	75	185	285	39	105	165
T60	120	280	430	60	160	260
T68	130	330	490	70	180	290
T68A	180	440	660	94	250	390
T72	150	400	630	79	220	360
T80	290	680	1020	150	400	610
T80B	430	1000	1500	230	590	910
T90	600	1350	2000	320	830	1250
T94	580	1300	1950	310	800	1200
T106	1100	2500	3800	580	1400	2300
T106A	800	1800	2650	410	1050	1600
T130	2000	4500	6700	1100	2700	4000
T131	1600	4400	6500	950	2600	4000
T157	4400	9600	13600	2450	5800	8550
T175	6800	14700	21500	3850	9000	13300
T184	8000	10700	20600	4900	11800	14600
T300	23400	50200	71900	14100	30700	45500
T400	65200	137000	201000	38900	85800	123000

FIGURES IN THIS TABLE APPLY TO BOTH GRAPHS ON THIS PAGE

	FULL WINDING		
	10°C	25°C	40°C
E49	23	65	105
E75	110	300	480
E100	310	700	1100
E137	1200	3000	6400
E162	2400	6000	9100
E168	4300	10300	15400
E168A	5600	13500	20200
E220	11000	28000	40000
E305	31000	75000	115000

QUICK REFERENCE A_L VALUES FOR -18 MATERIAL																				
PART NO.	T25	T26	T30	T37	T38	T44	T50	T50B	T60	T68	T72	T80	T80B	T94	T106	T106A	T130	T131	T157	T175
A_L VALUE	17.0	41.5	22.0	19.0	36.0	25.5	24.0	32.0	34.5	29.0	60.0	31.0	46.5	42.0	70.0	49.0	58.0	79.0	73.0	82.0
PART NO.	T184	T300	T400		E49	E75	E100	E137	E162	E168A	E220	E305								
A_L VALUE	116	58.0	96.0		29.0	45.5	65.0	100	149	170	196	222								



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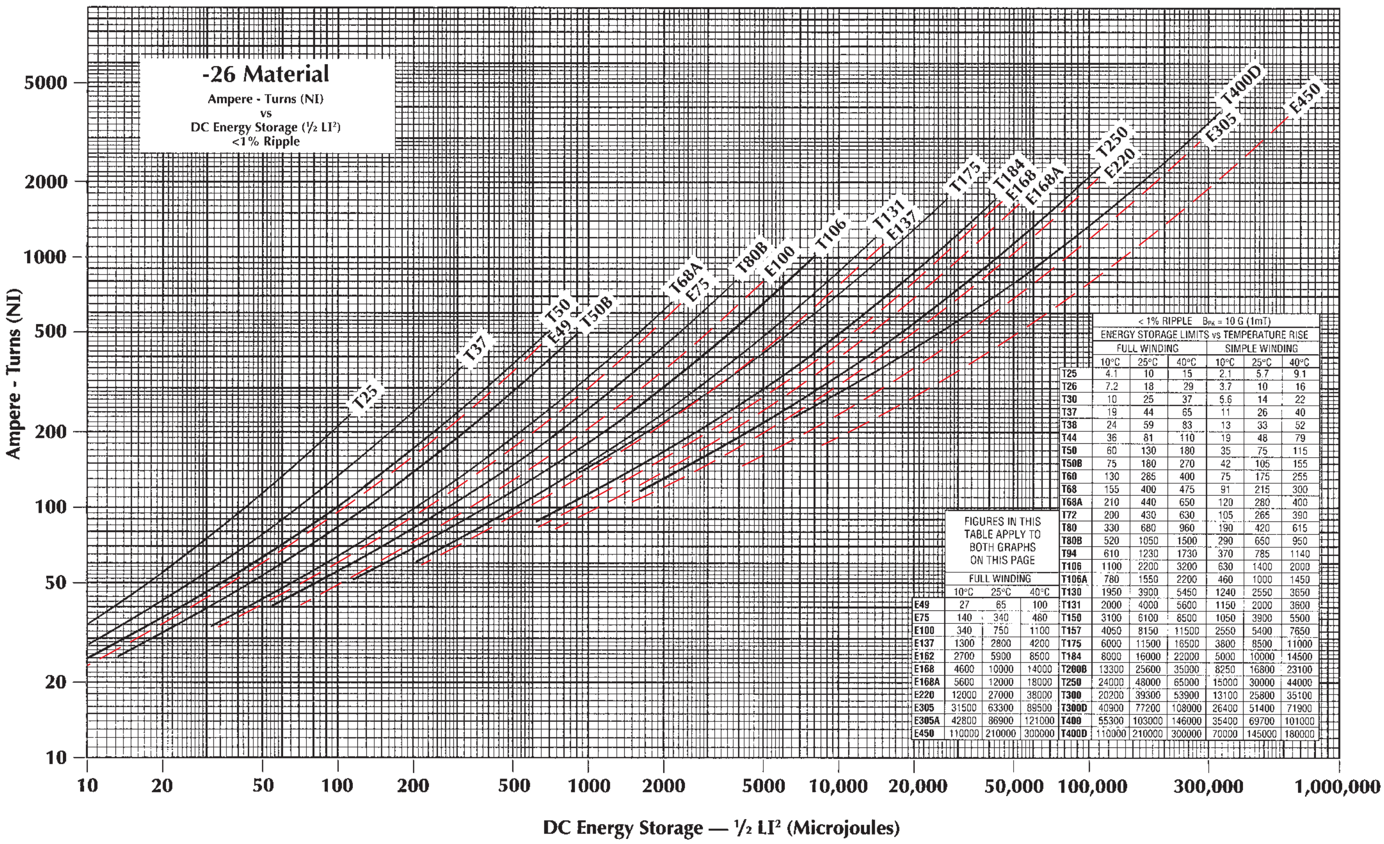


FIGURES IN THIS TABLE APPLY TO BOTH GRAPHS ON THIS PAGE

FULL WINDING	10°C	25°C	40°C
E49	27	65	100
E75	140	340	480
E100	340	750	1100
E137	1300	2800	4200
E162	2700	5900	8500
E168	4600	10000	14000
E168A	5600	12000	18000
E220	12000	27000	38000
E305	31500	63300	89500
E305A	42800	86900	121000
E450	110000	210000	300000

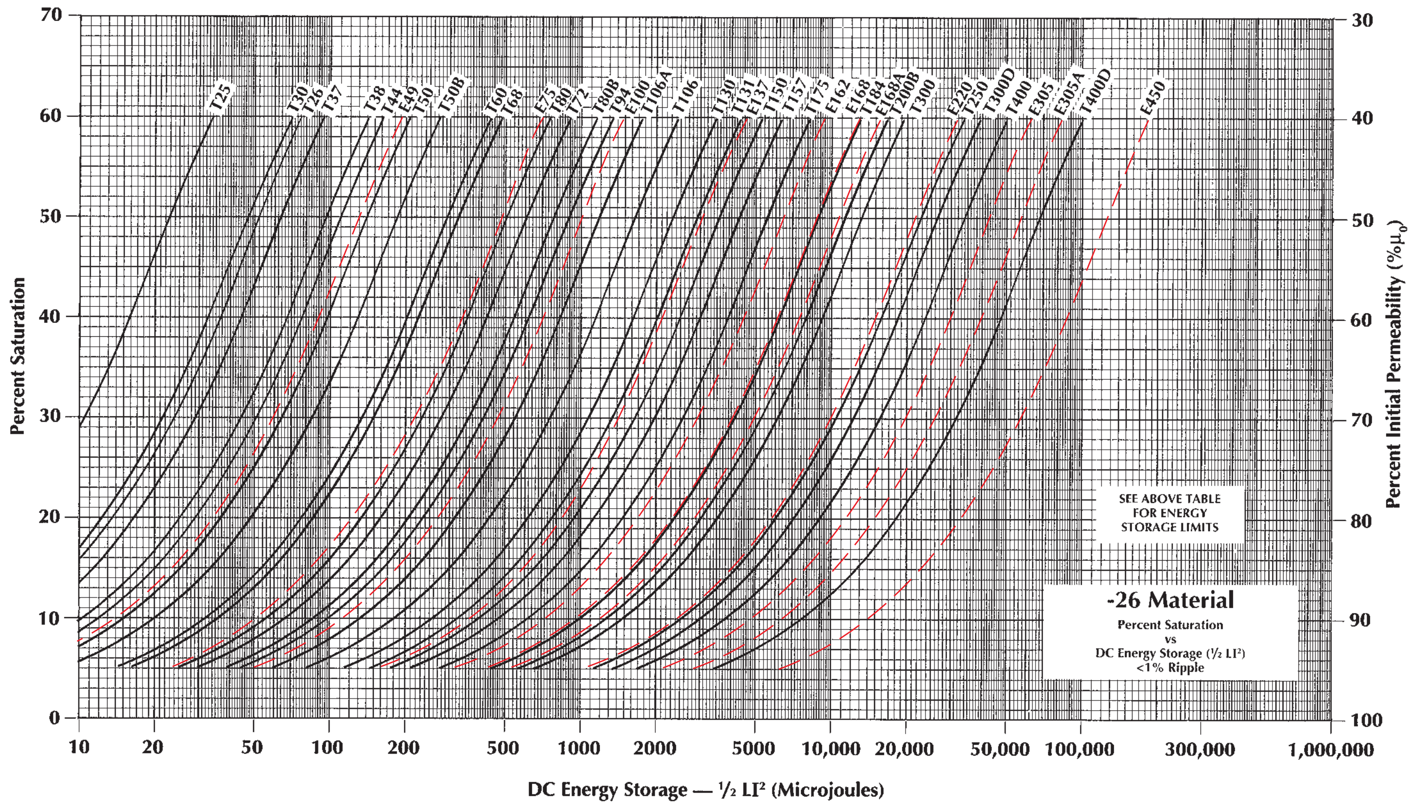
< 1% RIPPLE B_{PK} = 10 G (1mT)

ENERGY STORAGE LIMITS vs TEMPERATURE RISE

	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T25	4.1	10	15	2.1	5.7	9.1
T26	7.2	18	29	3.7	10	16
T30	10	25	37	5.6	14	22
T37	19	44	65	11	26	40
T38	24	59	83	13	33	52
T44	36	81	110	19	48	79
T50	60	130	180	35	75	115
T50B	75	180	270	42	105	155
T60	130	285	400	75	175	255
T68	155	400	475	91	215	300
T68A	210	440	650	120	280	400
T72	200	430	630	105	265	390
T80	330	680	960	190	420	615
T80B	520	1050	1500	290	650	950
T94	610	1230	1730	370	785	1140
T106	1100	2200	3200	630	1400	2000
T106A	780	1550	2200	460	1000	1450
T130	1950	3900	5450	1240	2550	3650
T131	2000	4000	5600	1150	2000	3600
T150	3100	6100	8500	1050	3900	5500
T157	4050	8150	11500	2550	5400	7650
T175	6000	11500	16500	3800	8500	11000
T184	8000	16000	22000	5000	10000	14500
T200B	13300	25600	35000	8250	16800	23100
T250	24000	48000	65000	15000	30000	44000
T300	20200	39300	53900	13100	25800	35100
T300D	40900	77200	108000	26400	51400	71900
T400	55300	103000	146000	35400	69700	101000
T400D	110000	210000	300000	70000	145000	180000

QUICK REFERENCE A_L VALUES FOR -26 MATERIAL

PART NO.	T25	T26	T30	T37	T38	T44	T50	T50B	T60	T68	T72	T80	T80B	T94	T106	T106A	T130	T131	T150	T157
A_L VALUE	24.5	57.0	33.5	28.5	49.0	37.0	33.0	43.5	50.0	43.5	90.0	46.0	71.0	60.0	93.0	67.0	81.0	116	96.0	100
PART NO.	T175	T184	T200B	T250	T300	T300D	T400	T400D		E49	E75	E100	E137	E162	E168	E168A	E220	E305	E305A	E450
A_L VALUE	105	169	160	242	80	160	131	262		38.0	64.0	92.0	134	210	195	232	275	287	382	540



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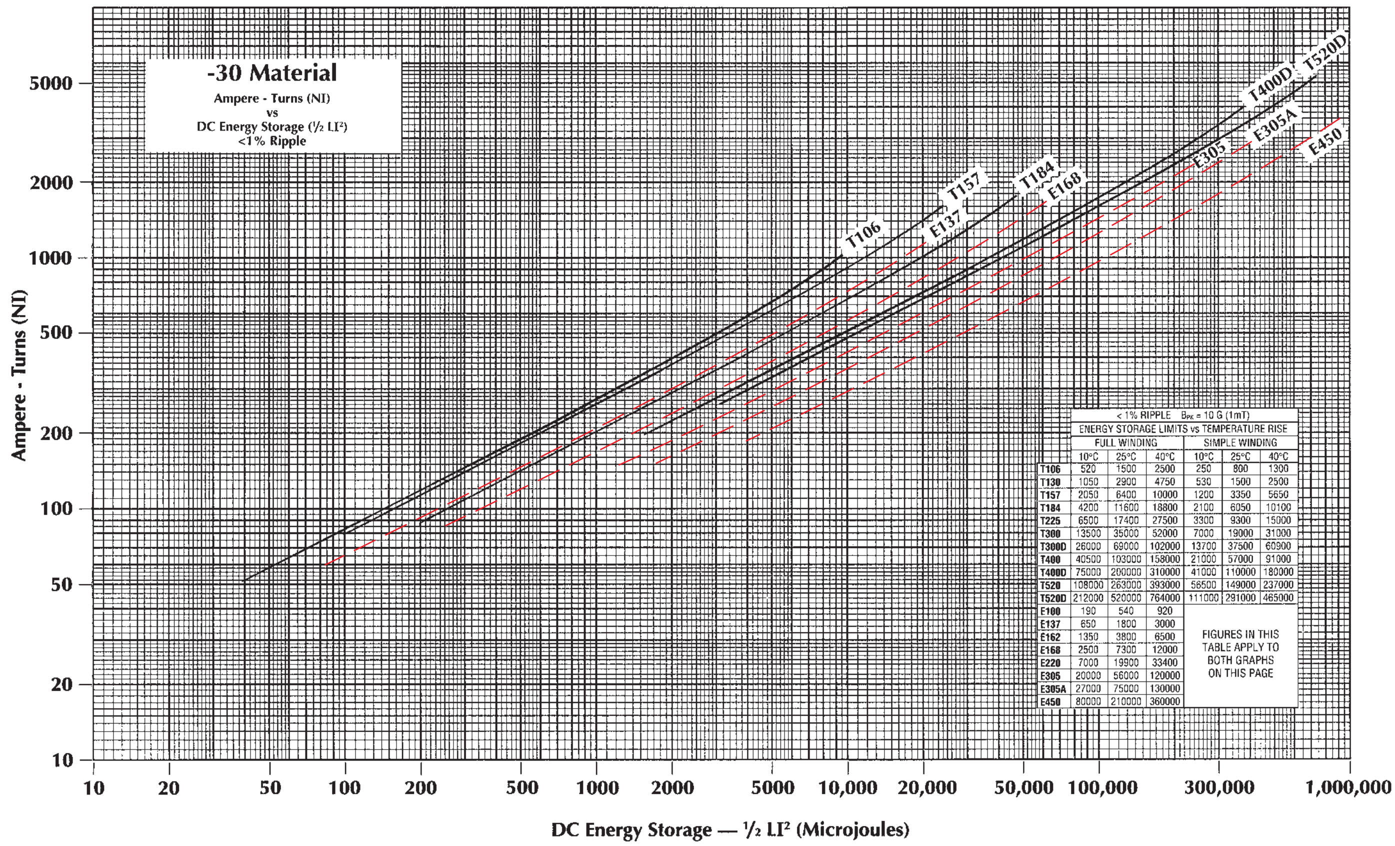
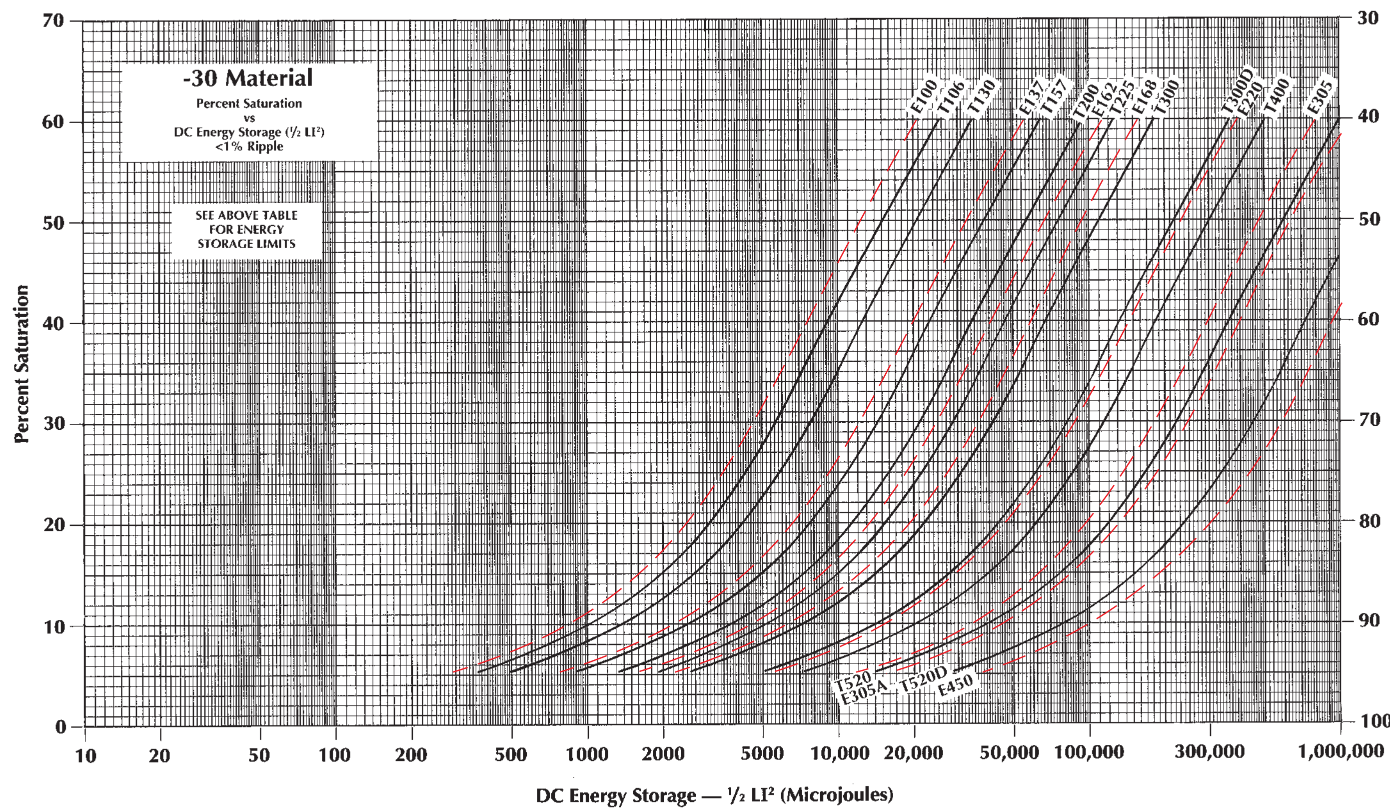


< 1% RIPPLE B_{PK} = 10 G (1mT)						
ENERGY STORAGE LIMITS vs TEMPERATURE RISE						
	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T106	520	1500	2500	250	800	1300
T130	1050	2900	4750	530	1500	2500
T157	2050	6400	10000	1200	3350	5650
T184	4200	11600	18800	2100	6050	10100
T225	6500	17400	27500	3300	9300	15000
T300	13500	35000	52000	7000	19000	31000
T300D	26000	69000	102000	13700	37500	60900
T400	40500	103000	158000	21000	57000	91000
T400D	75000	200000	310000	41000	110000	180000
T520	108000	263000	393000	56500	149000	237000
T520D	212000	520000	764000	111000	291000	465000
E100	190	540	920	FIGURES IN THIS TABLE APPLY TO BOTH GRAPHS ON THIS PAGE		
E137	650	1800	3000			
E162	1350	3800	6500			
E168	2500	7300	12000			
E220	7000	19900	33400			
E305	20000	56000	120000			
E305A	27000	75000	130000			
E450	80000	210000	360000			

QUICK REFERENCE A_L VALUES FOR -30 MATERIAL									
PART NO.	T106	T130	T157	T225	T300	T300D	T400	T520	T520D
A_L VALUE	30.0	25.0	31.5	28.0	23.0	46.0	40.5	45.0	90.0
PART NO.	E220	E305	E305A	E450					
A_L VALUE	107	124	165	235					



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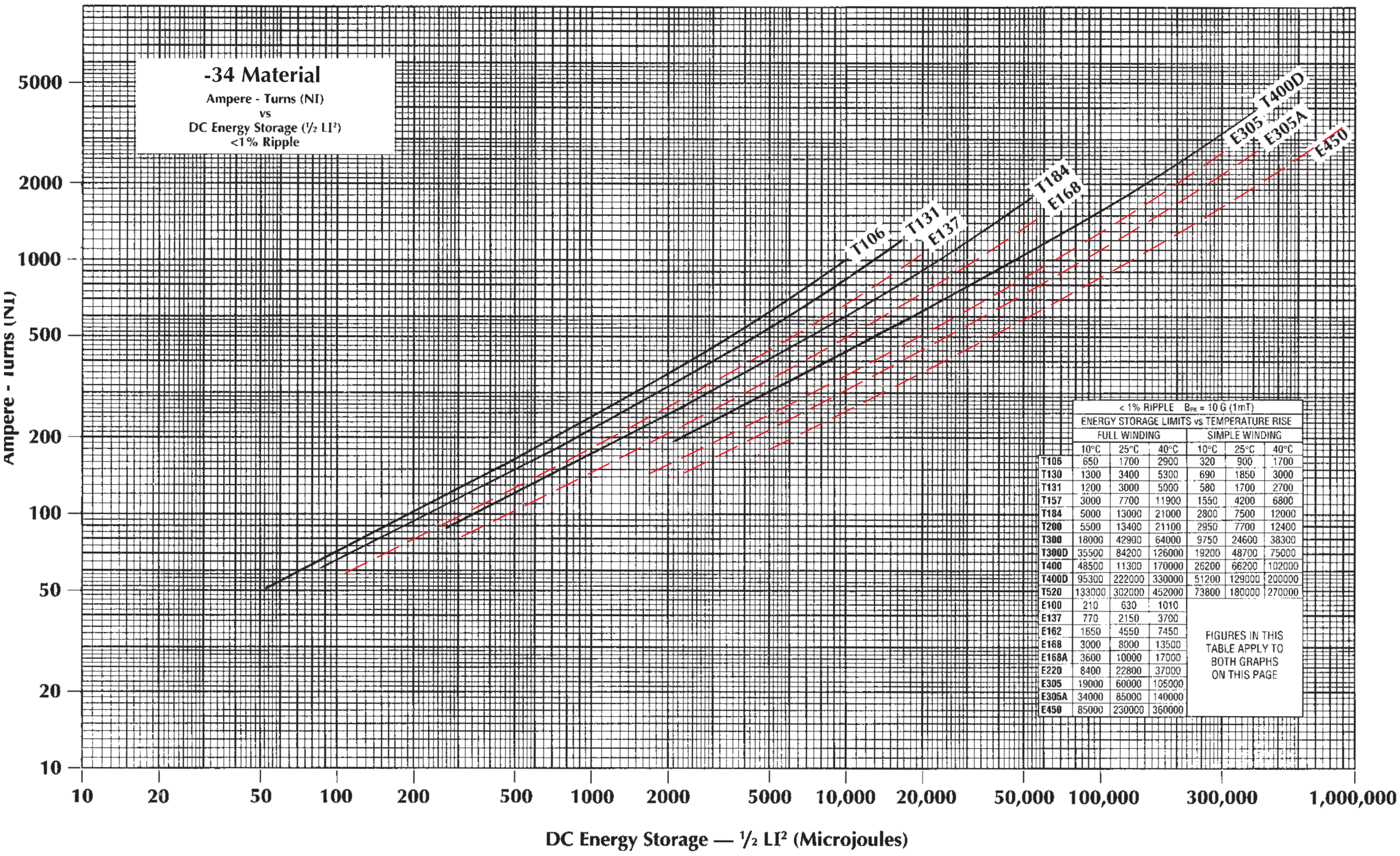
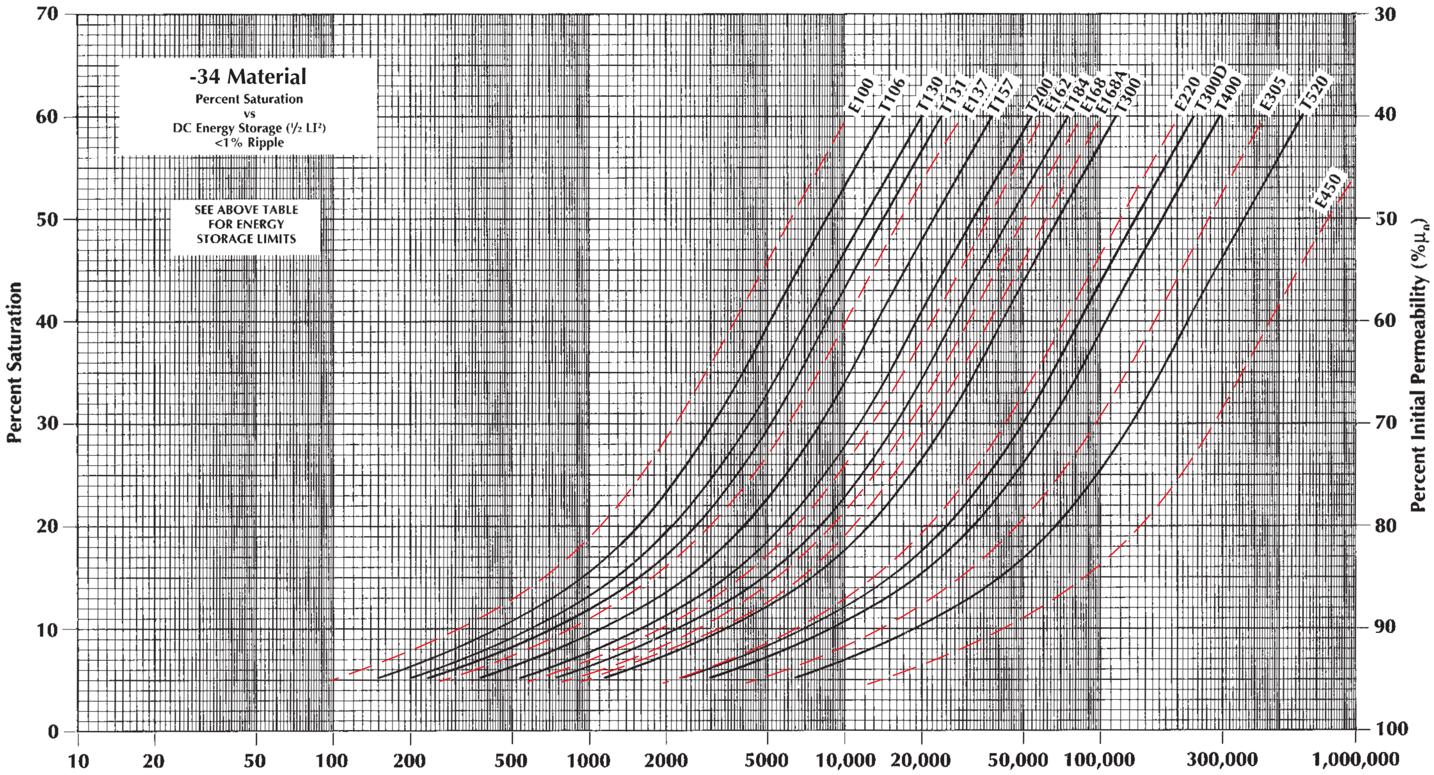


	< 1% RIPPLE B_{PK} = 10 G (1mT)					
	ENERGY STORAGE LIMITS vs TEMPERATURE RISE					
	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T106	650	1700	2900	320	900	1700
T130	1300	3400	5300	690	1850	3000
T131	1200	3000	5000	580	1700	2700
T157	3000	7700	11900	1550	4200	6800
T184	5000	13000	21000	2800	7500	12000
T200	5500	13400	21100	2950	7700	12400
T300	18000	42900	64000	9750	24600	38300
T300D	35500	84200	126000	19200	48700	75000
T400	48500	11300	170000	26200	66200	102000
T400D	95300	222000	330000	51200	129000	200000
T520	133000	302000	452000	73800	180000	270000
E100	210	630	1010	FIGURES IN THIS TABLE APPLY TO BOTH GRAPHS ON THIS PAGE		
E137	770	2150	3700			
E162	1650	4550	7450			
E168	3000	8000	13500			
E168A	3600	10000	17000			
E220	8400	22800	37000			
E305	19000	60000	105000			
E305A	34000	85000	140000			
E450	85000	230000	360000			

QUICK REFERENCE A_L VALUES FOR -34 MATERIAL

PART NO.	T106	T130	T131	T157	T184	T200	T300	T300D	T400	T520
A_L VALUE	40.0	33.5	46.5	43.5	70.0	37.0	34.5	69.0	55.0	65.0
PART NO.	E220	E305	E450							
A_L VALUE	136	150	300							



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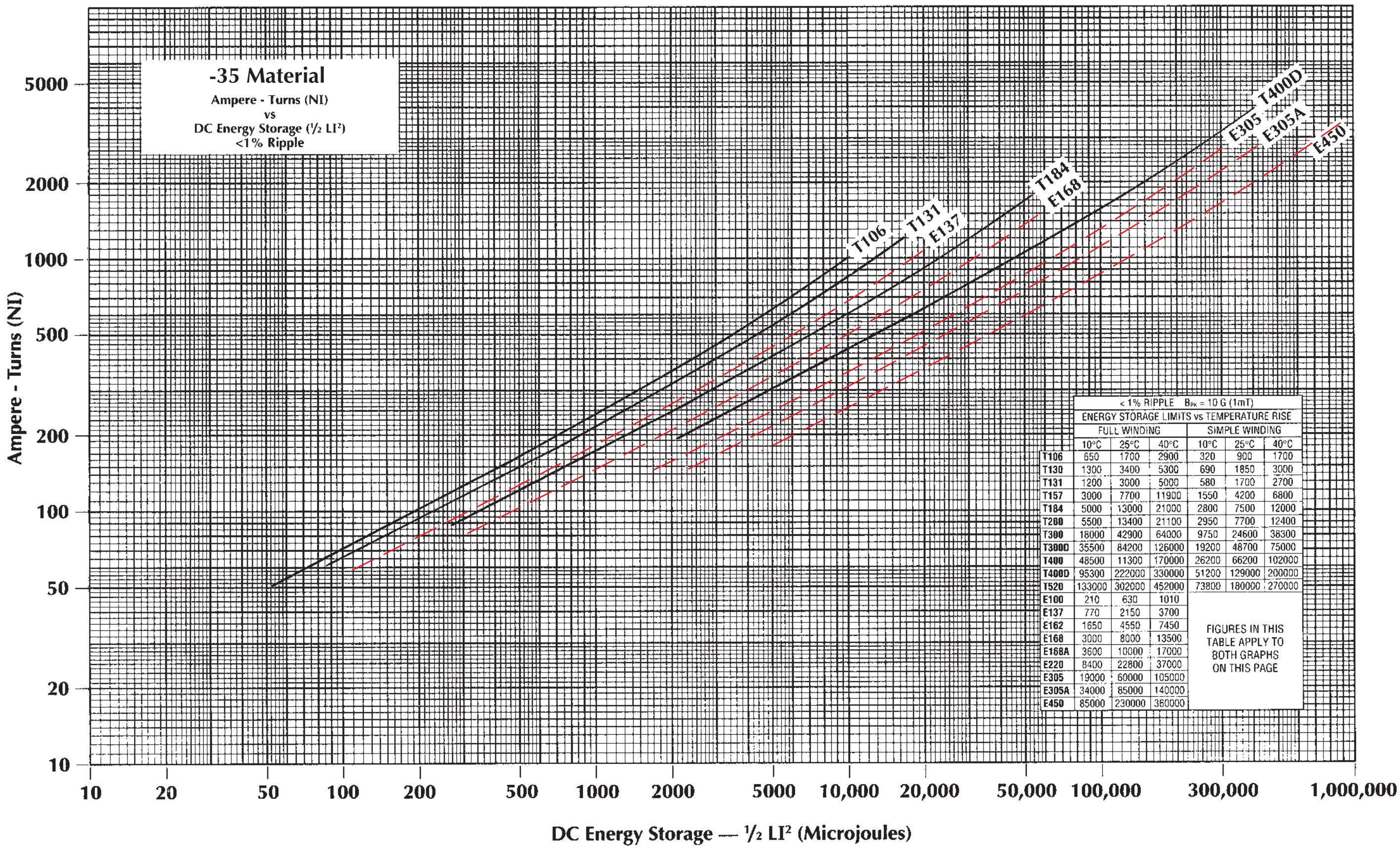
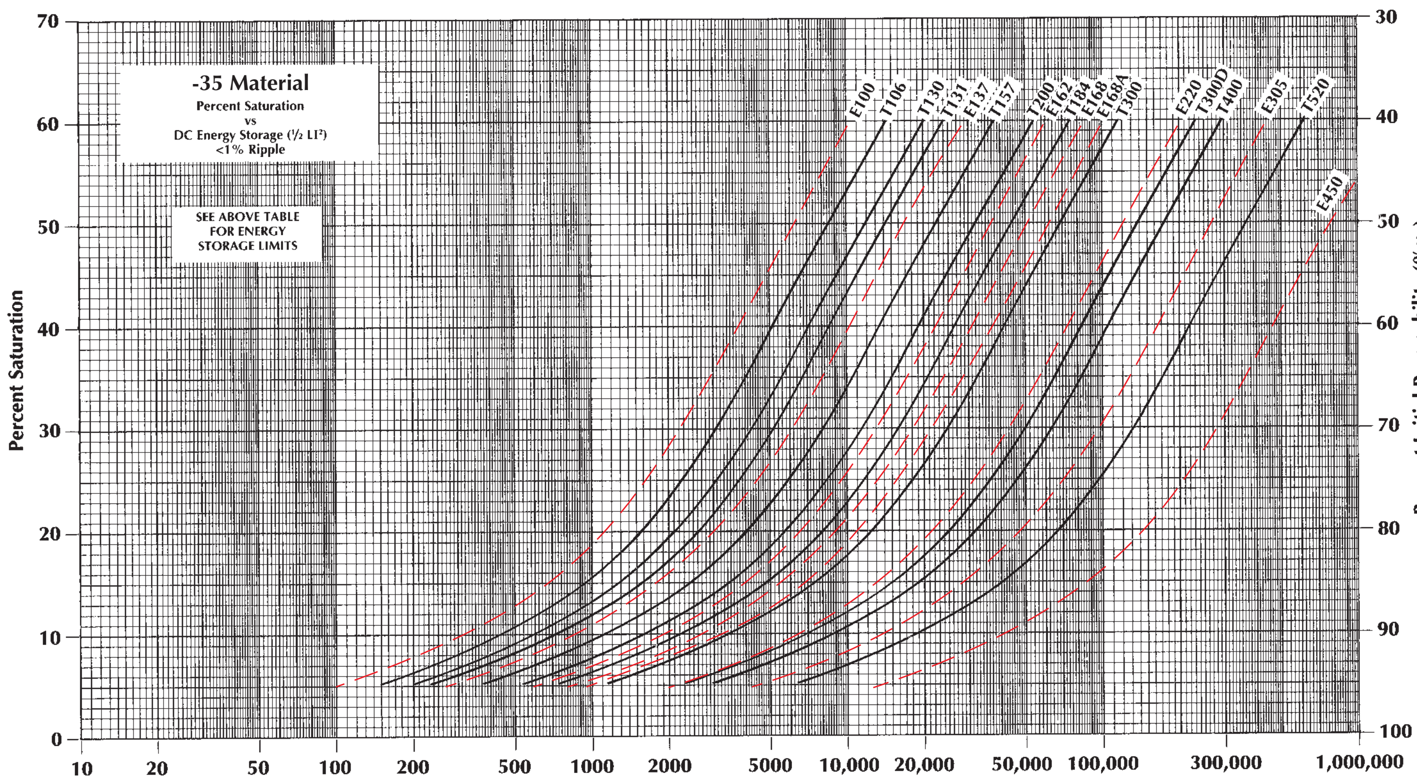


< 1% RIPPLE B_{PK} = 10 G (1mT)						
ENERGY STORAGE LIMITS vs TEMPERATURE RISE						
	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T106	650	1700	2900	320	900	1700
T130	1300	3400	5300	690	1850	3000
T131	1200	3000	5000	580	1700	2700
T157	3000	7700	11900	1550	4200	6800
T184	5000	13000	21000	2800	7500	12000
T200	5500	13400	21100	2950	7700	12400
T300	18000	42900	64000	9750	24600	38300
T300D	35500	84200	126000	19200	48700	75000
T400	48500	11300	170000	26200	66200	102000
T400D	95300	222000	330000	51200	129000	200000
T520	133000	302000	452000	73800	180000	270000
E100	210	630	1010			
E137	770	2150	3700			
E162	1650	4550	7450	FIGURES IN THIS TABLE APPLY TO BOTH GRAPHS ON THIS PAGE		
E168	3000	8000	13500			
E168A	3600	10000	17000			
E220	8400	22800	37000			
E305	19000	60000	105000			
E305A	34000	85000	140000			
E450	85000	230000	360000			

QUICK REFERENCE A_L VALUES FOR -35 MATERIAL										
PART NO.	T106	T130	T131	T157	T184	T200	T300	T300D	T400	T520
A_L VALUE	40.0	33.5	46.5	43.5	70.0	37.0	34.5	69.0	55.0	65.0
PART NO.	E220	E305	E450							
A_L VALUE	136	150	300							



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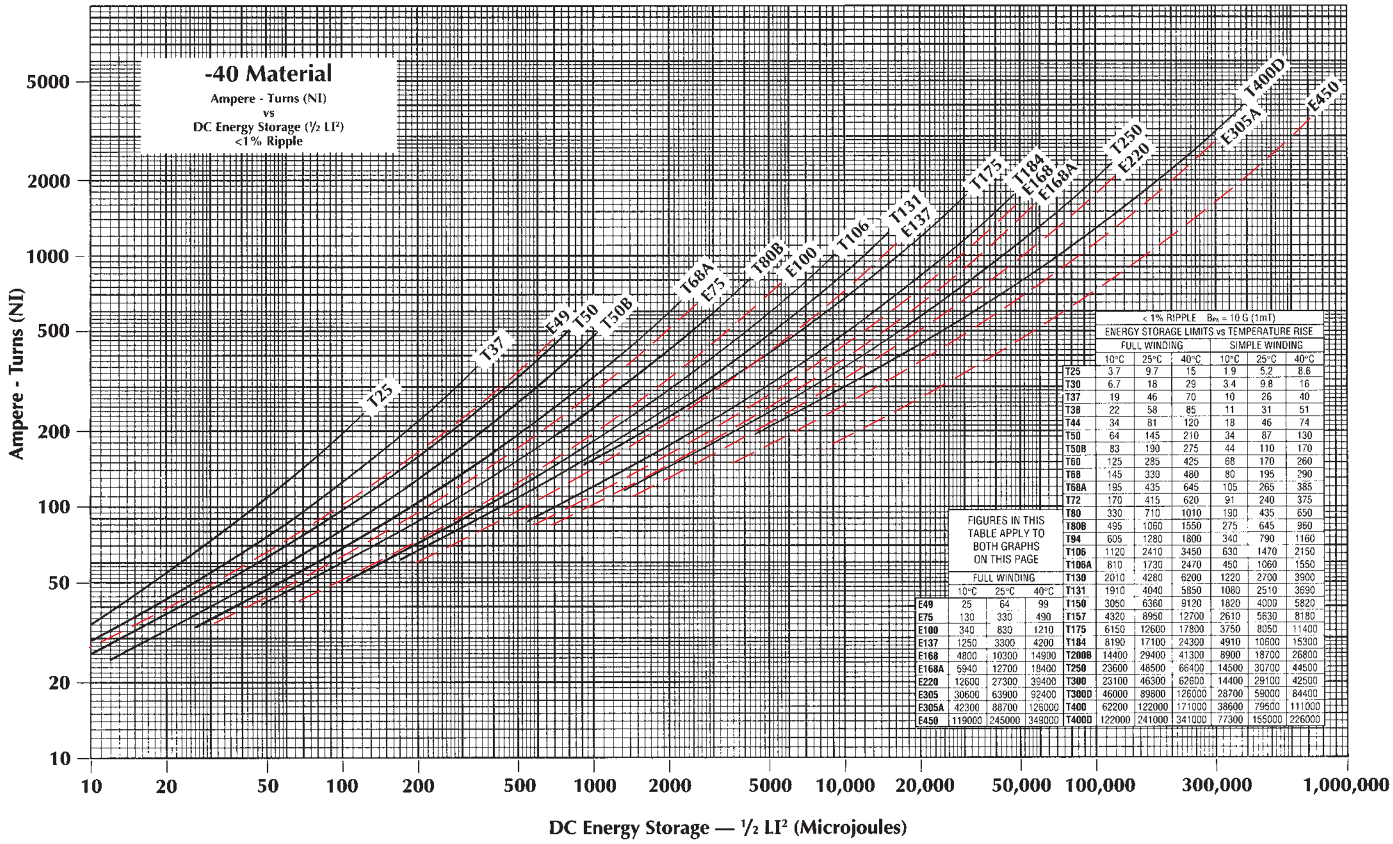


< 1% RIPPLE B_{PK} = 10 G (1mT)

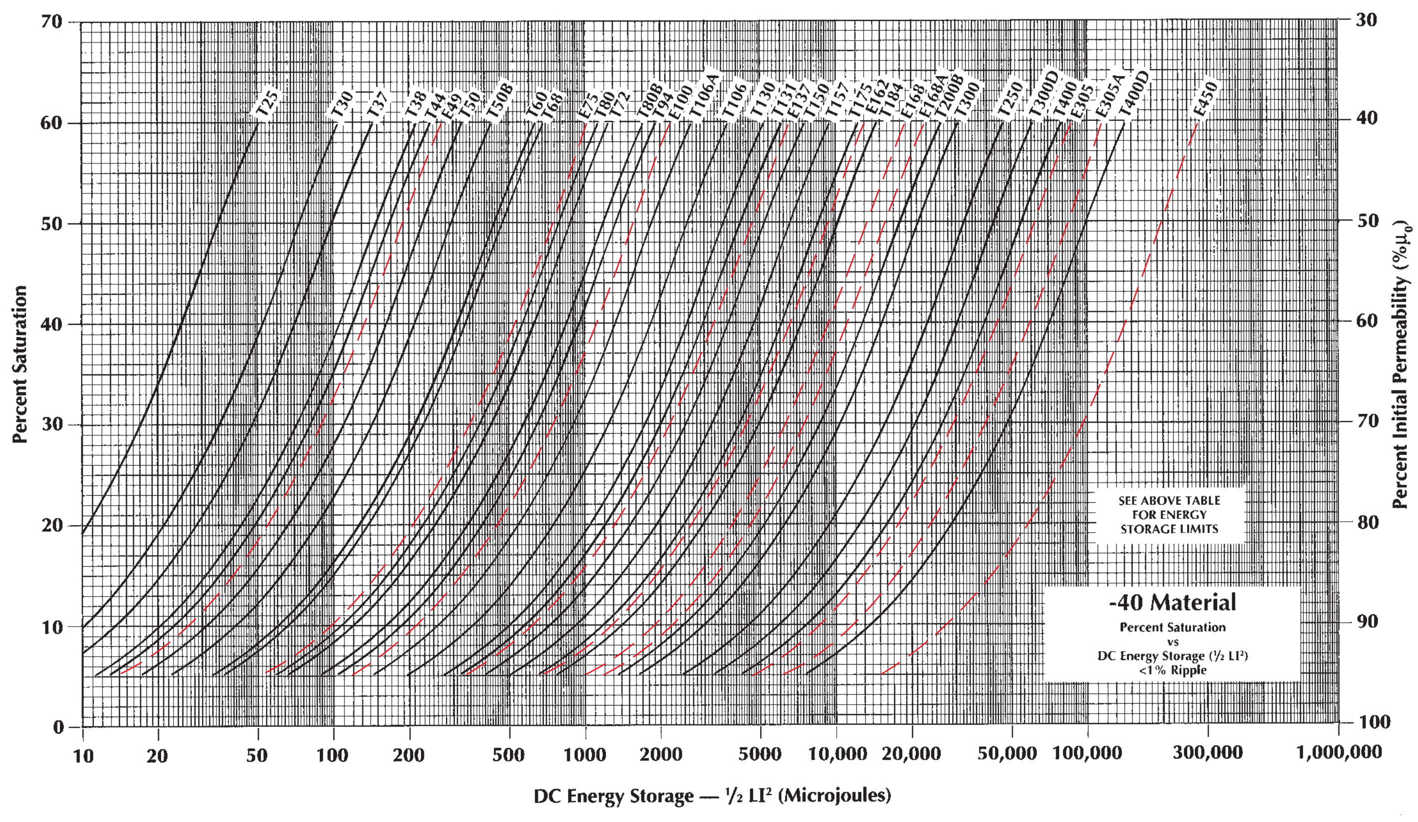
ENERGY STORAGE LIMITS vs TEMPERATURE RISE

	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T25	3.7	9.7	15	1.9	5.2	8.6
T30	6.7	18	29	3.4	9.8	16
T37	19	46	70	10	26	40
T38	22	58	85	11	31	51
T44	34	81	120	18	46	74
T50	64	145	210	34	87	130
T50B	83	190	275	44	110	170
T60	125	285	425	68	170	260
T68	145	330	480	80	195	290
T68A	195	435	645	105	265	385
T72	170	415	620	91	240	375
T80	330	710	1010	190	435	650
T80B	495	1060	1550	275	645	960
T94	605	1280	1800	340	790	1160
T106	1120	2410	3450	630	1470	2150
T106A	810	1730	2470	450	1060	1550
T130	2010	4280	6200	1220	2700	3900
T131	1910	4040	5850	1080	2510	3690
T150	3050	6360	9120	1820	4000	5820
T157	4320	8950	12700	2610	5630	8180
T175	6150	12600	17800	3750	8050	11400
T184	8190	17100	24300	4910	10600	15300
T200B	14400	29400	41300	8900	18700	26800
T250	23600	48500	66400	14500	30700	44500
T300	23100	46300	62600	14400	29100	42500
T300D	46000	89800	126000	28700	59000	84400
T400	62200	122000	171000	38600	79500	111000
T400D	122000	241000	341000	77300	155000	226000

	FULL WINDING		
	10°C	25°C	40°C
E49	25	64	99
E75	130	330	490
E100	340	830	1210
E137	1250	3300	4200
E168	4800	10300	14900
E168A	5940	12700	18400
E220	12600	27300	39400
E305	30600	63900	92400
E305A	42300	88700	126000
E450	119000	245000	349000

QUICK REFERENCE A_L VALUES FOR -40 MATERIAL

PART NO.	T25	T30	T37	T38	T44	T50	T50B	T60	T68	T72	T80	T80B	T94	T106	T106A	T130	T131	T150	T157	T175
A_L VALUE	20.5	28.0	24.5	41.5	31.0	29.5	38.5	41.5	35.0	71.0	39.5	59.0	49.0	81.0	58.0	69.0	93.0	78.0	86.0	90.0
PART NO.	T184	T200B	T250	T300	T300D	T400	T400D		E49	E75	E100	E137	E162	E168	E168A	E305	E305A	E450		
A_L VALUE	143	142	194	71.0	142	115	230		31.5	55.0	81.0	113	175	163	196	255	339	480		



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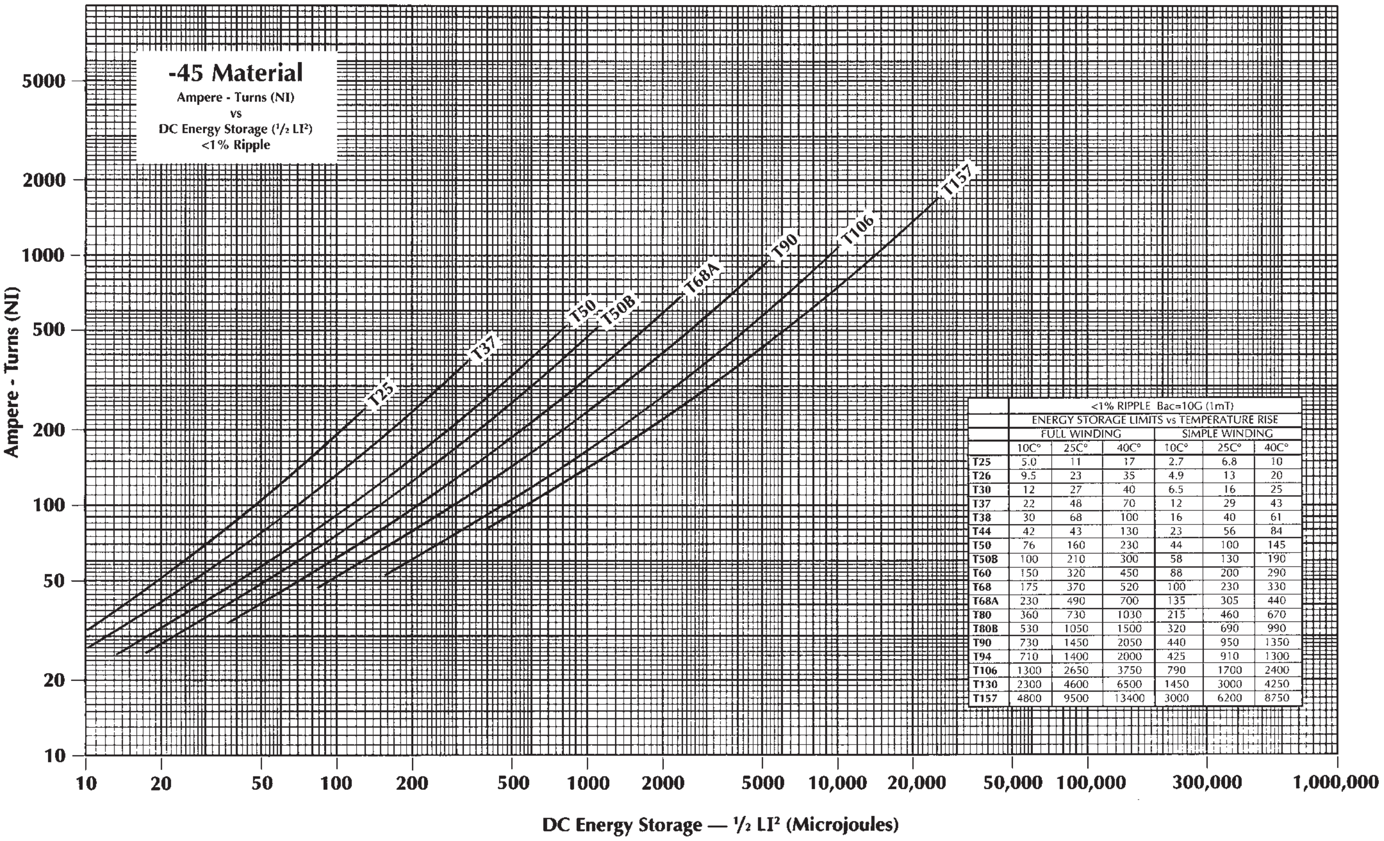
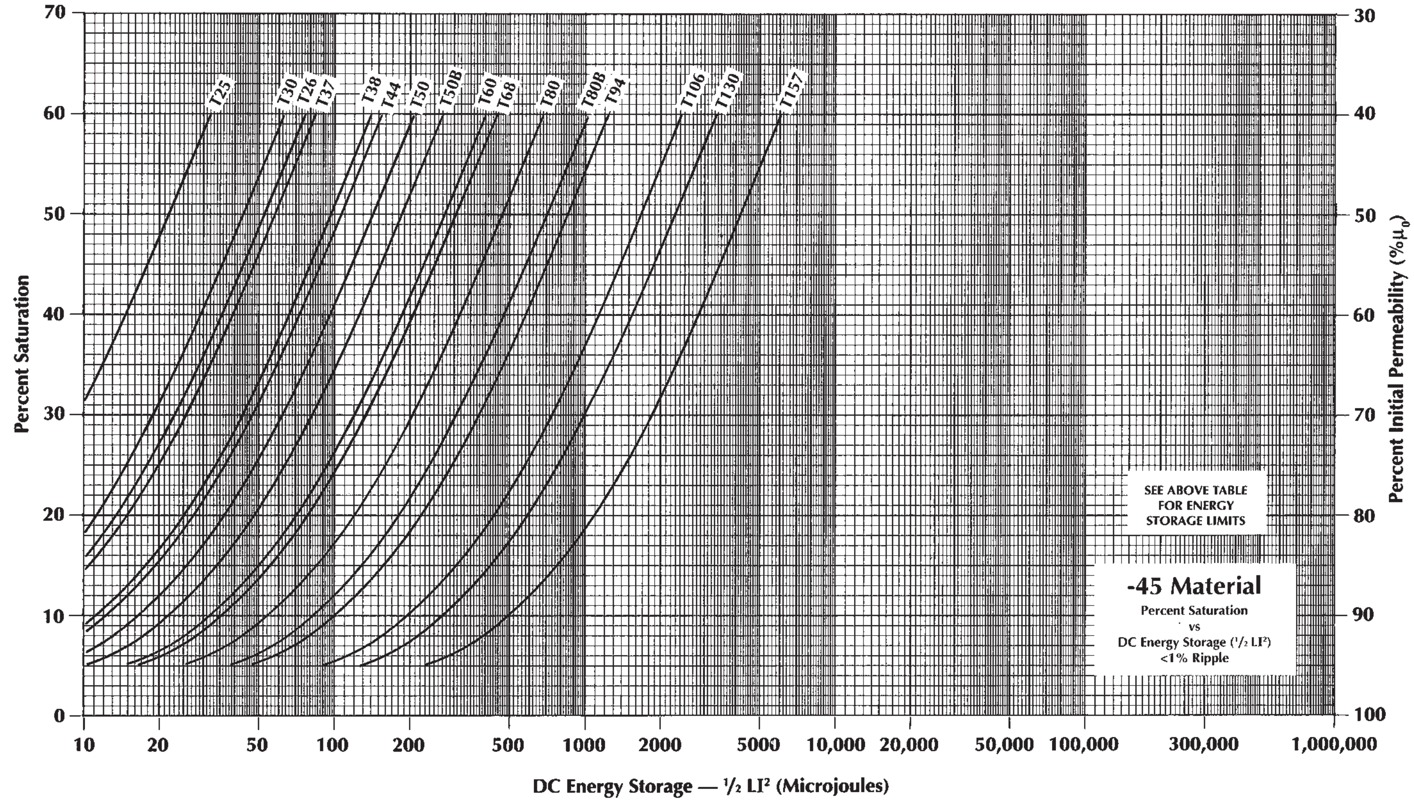


	<1% RIPPLE Bac=10G (1mT)					
	ENERGY STORAGE LIMITS vs TEMPERATURE RISE					
	FULL WINDING			SIMPLE WINDING		
	10C°	25C°	40C°	10C°	25C°	40C°
T25	5.0	11	17	2.7	6.8	10
T26	9.5	23	35	4.9	13	20
T30	12	27	40	6.5	16	25
T37	22	48	70	12	29	43
T38	30	68	100	16	40	61
T44	42	43	130	23	56	84
T50	76	160	230	44	100	145
T50B	100	210	300	58	130	190
T60	150	320	450	88	200	290
T68	175	370	520	100	230	330
T68A	230	490	700	135	305	440
T80	360	730	1030	215	460	670
T80B	530	1050	1500	320	690	990
T90	730	1450	2050	440	950	1350
T94	710	1400	2000	425	910	1300
T106	1300	2650	3750	790	1700	2400
T130	2300	4600	6500	1450	3000	4250
T157	4800	9500	13400	3000	6200	8750

QUICK REFERENCE A_L VALUES FOR -45 MATERIAL

PART NO.	T25	T26	T30	T37	T38	T44	T50	T50B	T60	T68	T68A	T80	T80B	T90	T94	T106	T130	T157		
A_L VALUE	31.0	77.0	40.5	34.0	65.0	46.5	44.0	58.0	62.0	53.0	71.0	56.0	84.0	85.0	76.0	125.0	105.0	130.0		



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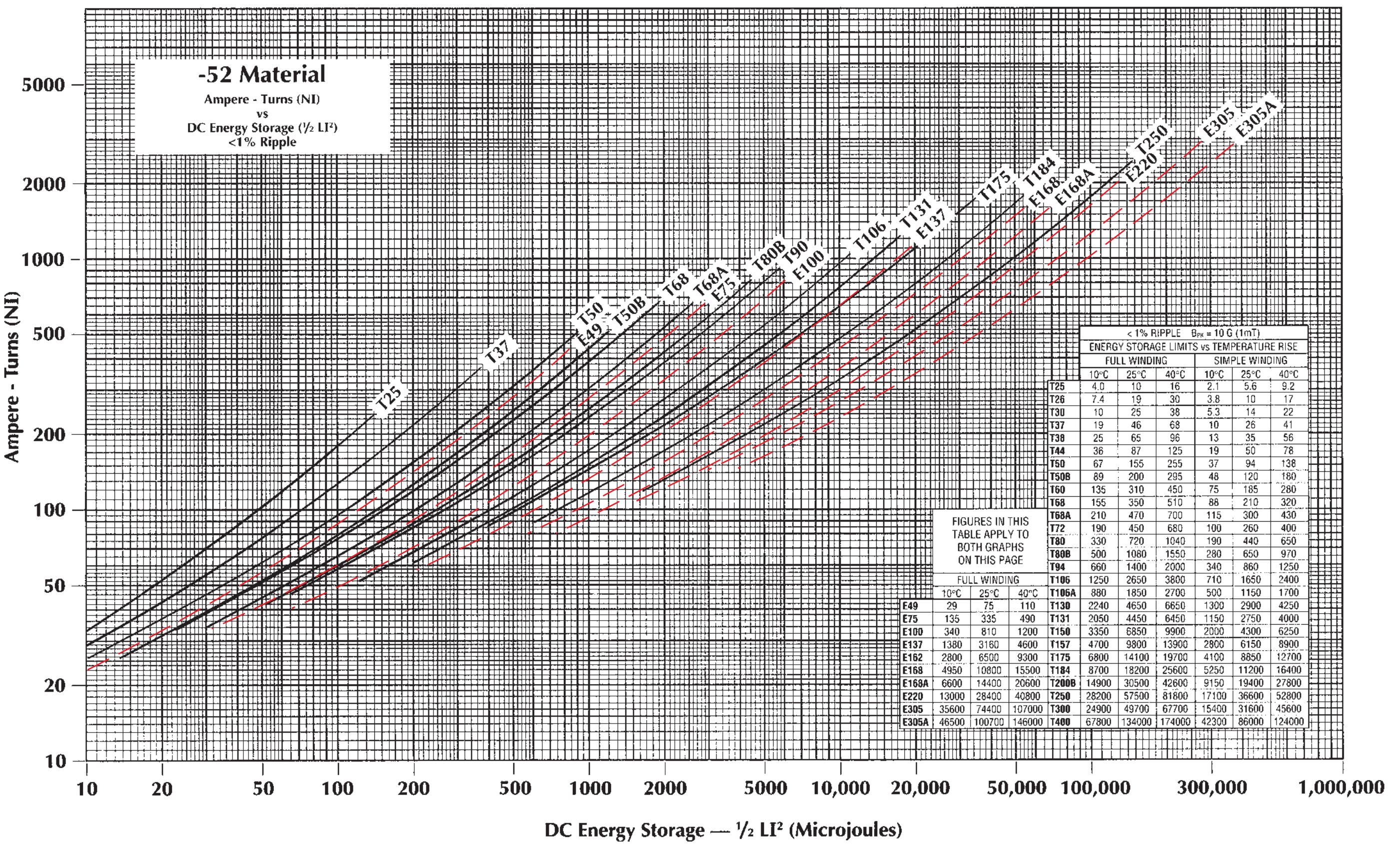
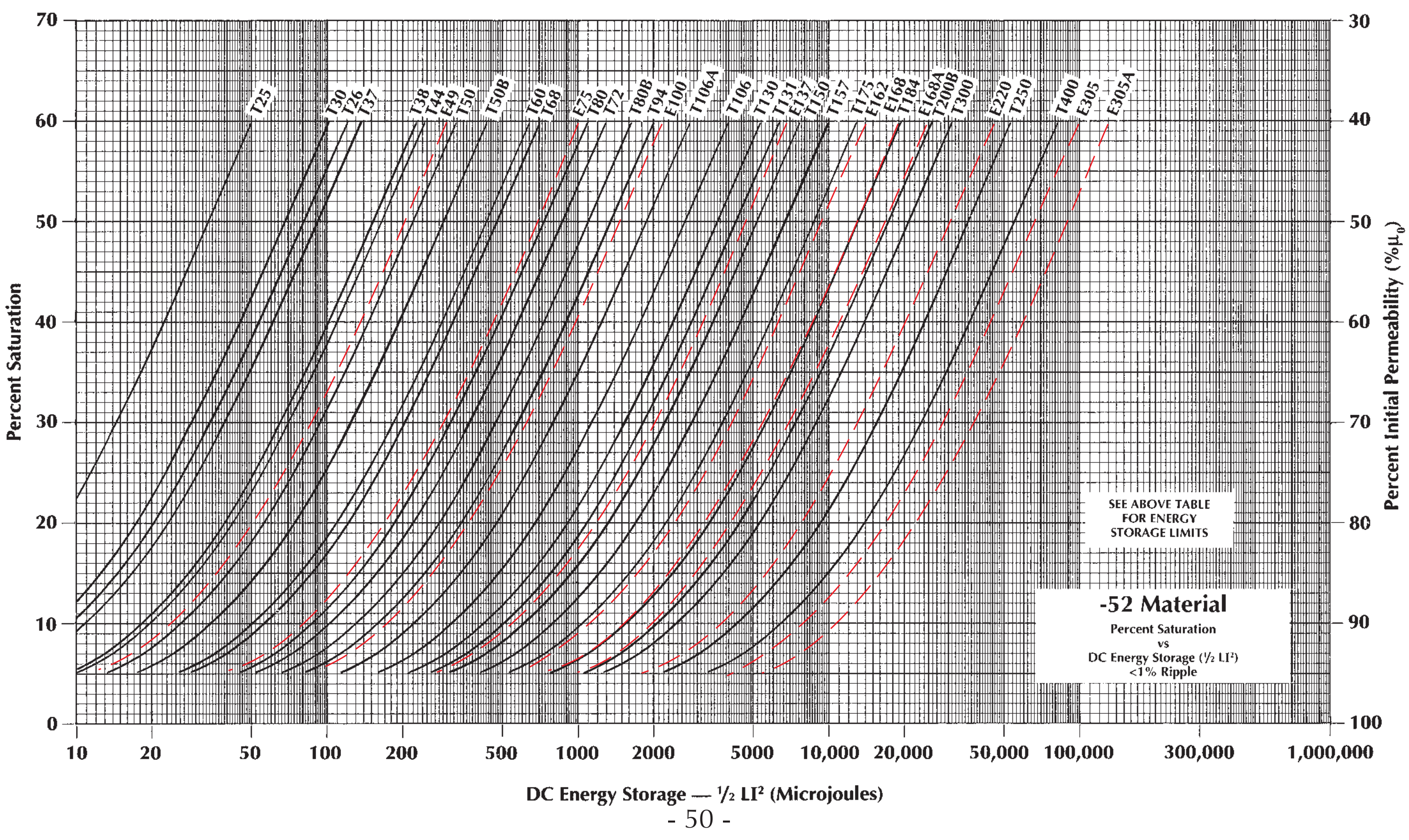


< 1% RIPPLE B_{PK} = 10 G (1mT)						
ENERGY STORAGE LIMITS vs TEMPERATURE RISE						
	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T25	4.0	10	16	2.1	5.6	9.2
T26	7.4	19	30	3.8	10	17
T30	10	25	38	5.3	14	22
T37	19	46	68	10	26	41
T38	25	65	96	13	35	56
T44	36	87	125	19	50	78
T50	67	155	255	37	94	138
T50B	89	200	295	48	120	180
T60	135	310	450	75	185	280
T68	155	350	510	88	210	320
T68A	210	470	700	115	300	430
T72	190	450	680	100	260	400
T80	330	720	1040	190	440	650
T80B	500	1080	1550	280	650	970
T94	660	1400	2000	340	860	1250
T106	1250	2650	3800	710	1650	2400
T106A	880	1850	2700	500	1150	1700
T130	2240	4650	6650	1300	2900	4250
T131	2050	4450	6450	1150	2750	4000
T150	3350	6850	9900	2000	4300	6250
T157	4700	9800	13900	2800	6150	8900
T175	6800	14100	19700	4100	8850	12700
T184	8700	18200	25600	5250	11200	16400
T200B	14900	30500	42600	9150	19400	27800
T250	28200	57500	81800	17100	36600	52800
T300	24900	49700	67700	15400	31600	45600
T400	67800	134000	174000	42300	86000	124000

FIGURES IN THIS TABLE APPLY TO BOTH GRAPHS ON THIS PAGE

	FULL WINDING		
	10°C	25°C	40°C
E49	29	75	110
E75	135	335	490
E100	340	810	1200
E137	1380	3160	4600
E162	2800	6500	9300
E168	4950	10800	15500
E168A	6600	14400	20600
E220	13000	28400	40800
E305	35600	74400	107000
E305A	46500	100700	146000

QUICK REFERENCE A_L VALUES FOR -52 MATERIAL																			
PART NO.	T25	T26	T30	T37	T38	T44	T50	T50B	T60	T68	T72	T80	T80B	T94	T106	T106A	T130	T131	T150	T157
A_L VALUE	23.0	56.0	30.5	26.0	49.0	35.0	33.0	43.5	47.0	40.0	82.0	42.0	63.0	57.0	95.0	67.0	79.0	108	89.0	99.0
PART NO.	T175	T184	T200B	T250	T300	T400		E49	E75	E100	E137	E162	E168	E168A	E220	E305	E305A			
A_L VALUE	105	159	155	242	80.0	131		38.0	59.0	85.0	131	199	179	230	262	287	382			



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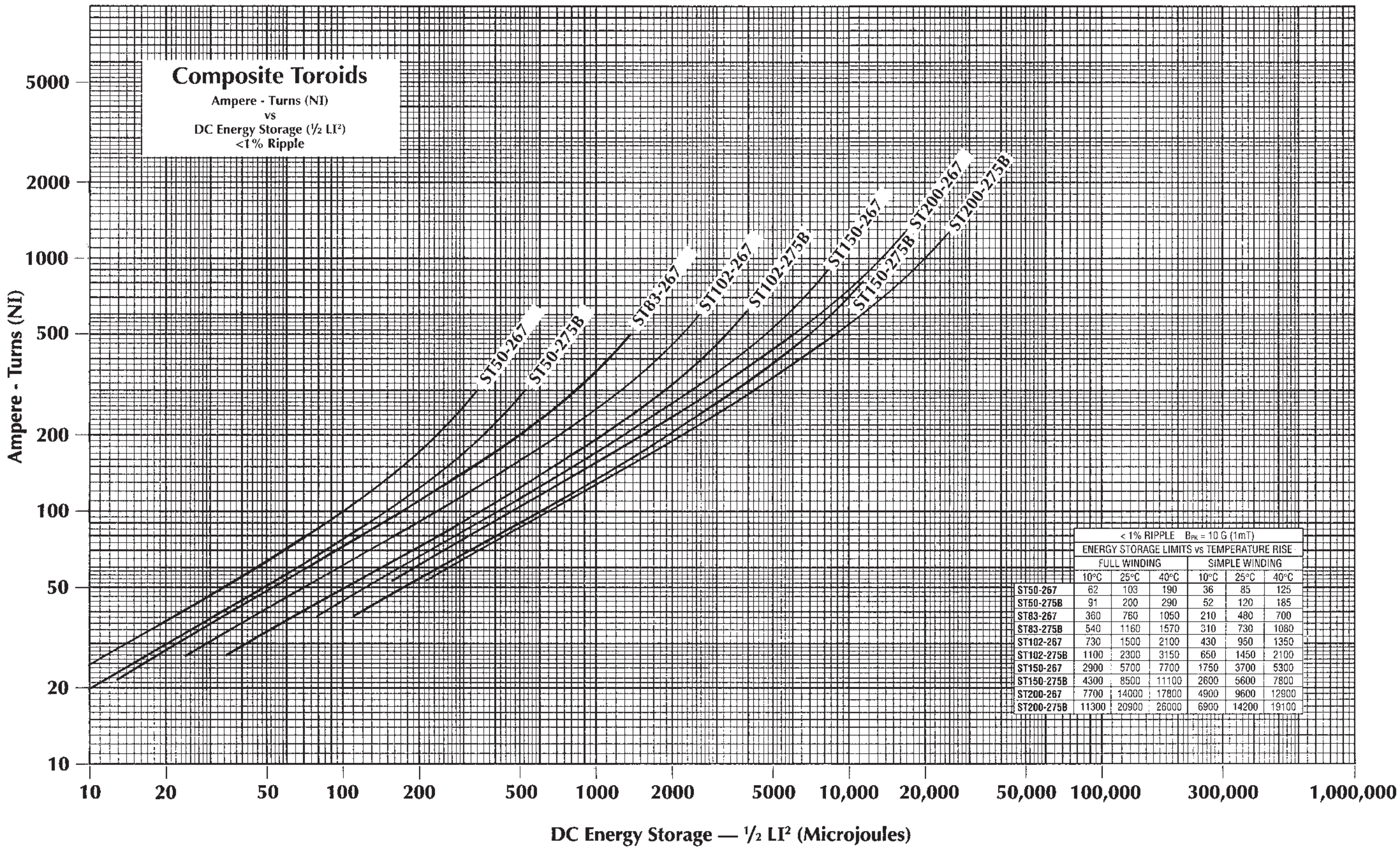
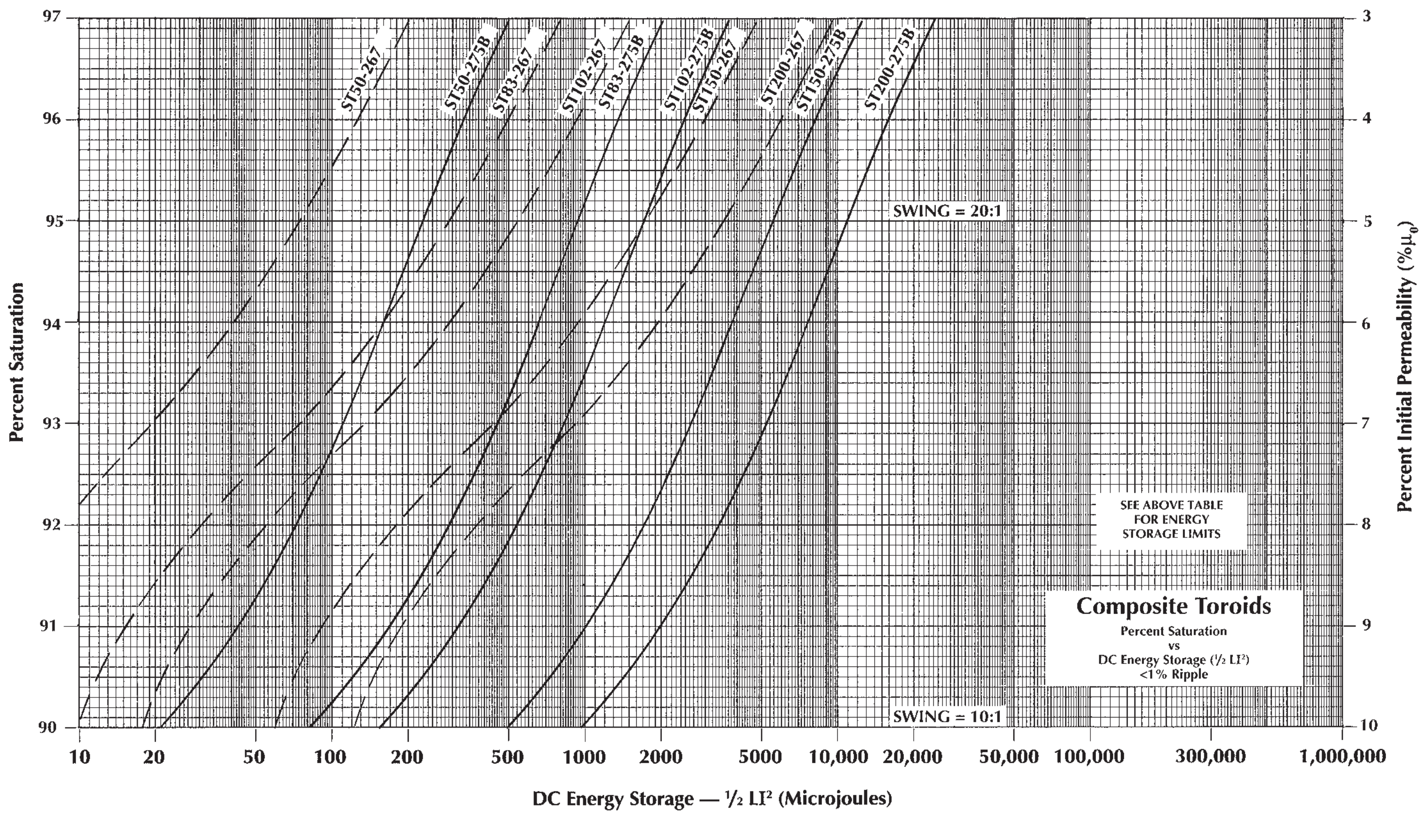


	< 1% RIPPLE B_{PK} = 10 G (1mT)					
	ENERGY STORAGE LIMITS vs TEMPERATURE RISE					
	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
ST50-267	62	103	190	36	85	125
ST50-275B	91	200	290	52	120	185
ST83-267	360	760	1050	210	480	700
ST83-275B	540	1160	1570	310	730	1080
ST102-267	730	1500	2100	430	950	1350
ST102-275B	1100	2300	3150	650	1450	2100
ST150-267	2900	5700	7700	1750	3700	5300
ST150-275B	4300	8500	11100	2600	5600	7800
ST200-267	7700	14000	17800	4900	9600	12900
ST200-275B	11300	20900	26000	6900	14200	19100

QUICK REFERENCE A_L VALUES FOR COMPOSITE TOROIDS										
PART NO.	ST50-267	ST50-275B	ST83-267	ST83-275B	ST102-267	ST102-275B	ST150-267	ST150-275B	ST200-267	ST200-275B
A_L VALUE	450	475	625	650	800	825	1250	1300	1275	1325



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DC INDUCTOR DESIGN EXAMPLES

EXAMPLE #1

Requirements: 45 µH at 7.75 amps DC
(< 1% ripple current)

Determine importance of the following design considerations: component size, temperature rise and cost.

Example #1: Design Priorities
cost
temperature rise
component size

Select appropriate materials to be considered.

-26, -52 and -40 Materials should be considered since the inductor requirements do not limit swing and these materials are the most cost effective.

Calculate the required Energy Storage (1/2 LI^2)

$\frac{1}{2} LI^2 = (\frac{1}{2})(45)(7.5)^2 = 1266$ µJ

Select core size and shape

-26 Material will be used in this example.
Refer to the Energy Storage Table on page 40. The T106 size toroid will be selected in order to keep the winding "simple" and the temerature rise around 25C°. The E137 is an attractive choice if bobbin winding is preferred.

Determine number of turns

The curve at the top of page 40 indicates the T106 will require 217 ampere-turns to produce 1266 µJ.

Therefore,
NI = 162 / 7.5 = 29 turns

In the case of the E137 core, the curves indicate that 162 ampere-turns will be required to provide 1266 µJ.

Therefore,
NI = 162 / 7.5 = 22 turns

Determine wire size

In the case of the T106 toroidal core, the "simple" winding limits are close estimates of typical single layer windings, refer to the Single Layer Winding Table on page 60. This table shows that #7 wire will fit in a single layer and result in a 25C° temperature rise from the wire. In the case of the E137, referring to the Full Winding Table on page 61 indicates that up to #13 wire can be used.

Solution: T106-26 with 29 turns #17
or E137-26 with 22 turns #14

EXAMPLE #2

Requirements: 45 µH at 7.75 amps DC
60 µH max at 0 amps DC
(25% saturation max)
(< 1% ripple current)

Example #2: Design Priorities
component size
temperature rise
cost

-8, -18, -28 and -33 Materials should be considered because of the limited swing requirements.

$\frac{1}{2} LI^2 = (\frac{1}{2})(45)(7.5)^2 = 1266$ µJ

The -8 Material is the best choice since component size is the primary concern.
The Energy Storage Table on page 38 indicates that the T94 size toroid is the smallest core able to meet the energy storage requirements at < 40C° temperature rise. We must also check the % saturation curves (page 38 bottom) to verify that this core will be operating at less than 25% saturation.

The curves at the bottom of page 38 indicate that the T94 will be operating at 84.5% of initial permeability (15.5% saturation) to produce 1266 µJ. Use the following formula to calculate turns:

$$N = \left[\frac{\text{desired L (nH)}}{(A_L)(\%\mu_o)}\right]^{1/2}$$

$$N = \left[\frac{45{,}000}{(25.0)(.85)}\right]^{1/2} = 46 \text{ turns}$$

Since a "full" winding was required to keep the temperature rise of the T94 below 40C°, refer to the winding table on page 60. This table indicates that #16 wire should be used.

This table also contains the information necessary to calculate the DC resistance of a winding.

Solution: Part number T94-8/90
with 46 turns #16

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DC Inductor Examples

Note: This table assumes < 1% ripple current. The presence of significant ripple current will result in both greater inductance and higher operating temperature.

TOROIDAL CORES: SINGLE LAYER WINDINGS

PART # \ DC CURRENT WIRE * SIZE	1.0 amps #28 AWG	2.5 amps #24 AWG	5.0 amps #20 AWG	7.5 amps #18 AWG	10 amps #15 AWG	15 amps #13 AWG	20 amps #11 AWG	30 amps #9 AWG
T50-52	94 µH *59 turns*	30.7 µH *37 turns*	10.2 µH *22 turns*	5.0 µH *16 turns*	2.8 µH *12 turns*	1.3 µH *8 turns*	0.7 µH *6 turns*	0.2 µH *3 turns*
T68-52A	250 µH *74 turns*	81.6 µH *46 turns*	27.6 µH *28 turns*	16.7 µH *21 turns*	8.3 µH *16 turns*	4.4 µH *12 turns*	2.1 µH *8 turns*	0.8 µH *5 turns*
T90-52	680 µH *115 turns*	224 µH *72 turns*	74.0 µH *44 turns*	40.9 µH *34 truns*	23.6 µH *26 turns*	13.0 µH *20 turns*	7.3 µH *15 turns*	3.7 µH *11 turns*
T106-52	1,080 µH *118 turns*	362 µH *74 turns*	124 µH *46 turns*	69.3 µH *36 turns*	39.0 µH *27 turns*	21.3 µH *21 turns*	11.4 µH *15 turns*	5.8 µH *11 turns*
T131-52	1,660 µH *134 turns*	550 µH *85 truns*	188 µH *52 turns*	107 µH *41 turns*	63.0 µH *32 turns*	33.3 µH *24 turns*	18.8 µH *18 turns*	9.2 µH *13 turns*
T157-52	3,320 µH *204 turns*	1,090 µH *129 turns*	380 µH *81 turns*	213 µH *64 turns*	127 µH *50 turns*	69.3 µH *39 turns*	40.1 µH *30 turns*	21.5 µH *23 turns*
T184-52	5,400 µH *202 turns*	1,790 µH *129 turns*	624 µH *81 turns*	345 µH *63 turns*	210 µH *50 turns*	114 µH *38 turns*	65.0 µH *29 turns*	34.0 µH *22 turns*
T250-52	14,800 µH *270 turns*	4,960 µH *172 turns*	1,720 µH *108 turns*	978 µH *86 turns*	591 µH *67 turns*	332 µH *59 turns*	195 µH *41 turns*	102 µH *31 turns*
T400-52	26,100 µH *494 turns*	8,690 µH *317 turns*	3,100 µH *160 turns*	1,760 µH *157 turns*	1,050 µH *126 turns*	590 µH *100 turns*	347 µH *78 turns*	190 µH *61 turns*

E CORES: FULL BOBBIN WINDINGS

PART # \ DC CURRENT WIRE * SIZE	2.5 amps #20 AWG	5.0 amps #18 AWG	10 amps #14 AWG	15 amps #12 AWG	20 amps #11 AWG	30 amps FOIL	50 amps FOIL	100 amps FOIL
E137-52	976 µH *112 turns*	348 µH *71 turns*	64.0 µH *29 turns*	25.8 µH *18 turns*	15.3 µH *14 turns*	8.7 µH *11 turns*	3.4 µH *7 turns*	0.7 µH *3 turns*
E168-52	4,000 µH *212 turns*	1,420 µH *136 turns*	260 µH *55 turns*	105 µH *34 turns*	64.0 µH *27 turns*	41.1 µH *20 turns*	9.2 µH *10 turns*	3.0 µH *6 turns*
E220-52	11,700 µH *303 turns*	4,080 *194 turns*	760 µH *78 turns*	311 µH *49 turns*	190 µH *39 turns*	88.9 µH *27 turns*	32.0 µH *16 turns*	8.0 µH *8 turns*

* Based on max temperature rise of $40C^{o}$ due to copper and core loss

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DC APPLICATIONS

GAPPING IRON POWDER E CORES

Gapping iron powder E Cores increases energy storage capabilities beyond that inherent in the distributed air gap structure that is characteristic of the material. Gapping of E Cores is advantageous only in the higher permeability -26, -40 and -52 Materials due to ampere-turn temperature rise limitations.

The graphs below and to the right illustrate the typical effect of gapping on the basic magnetic characteristics of -26 Material. The magnetization curves for the E Core geometry vary somewhat from curves for toroidal cores. This difference is due to the variation in leakage between the geometries. Similarly, some variation will exist between particular E Cores sizes. These curves are for reference only.

Similar results occur for -40 and -52 Materials. While -40 Material has an initial permeability approximately 20% lower than -26 and -52 Materials, when the two materials are gapped the resulting effective permeabilities are much closer to one another.

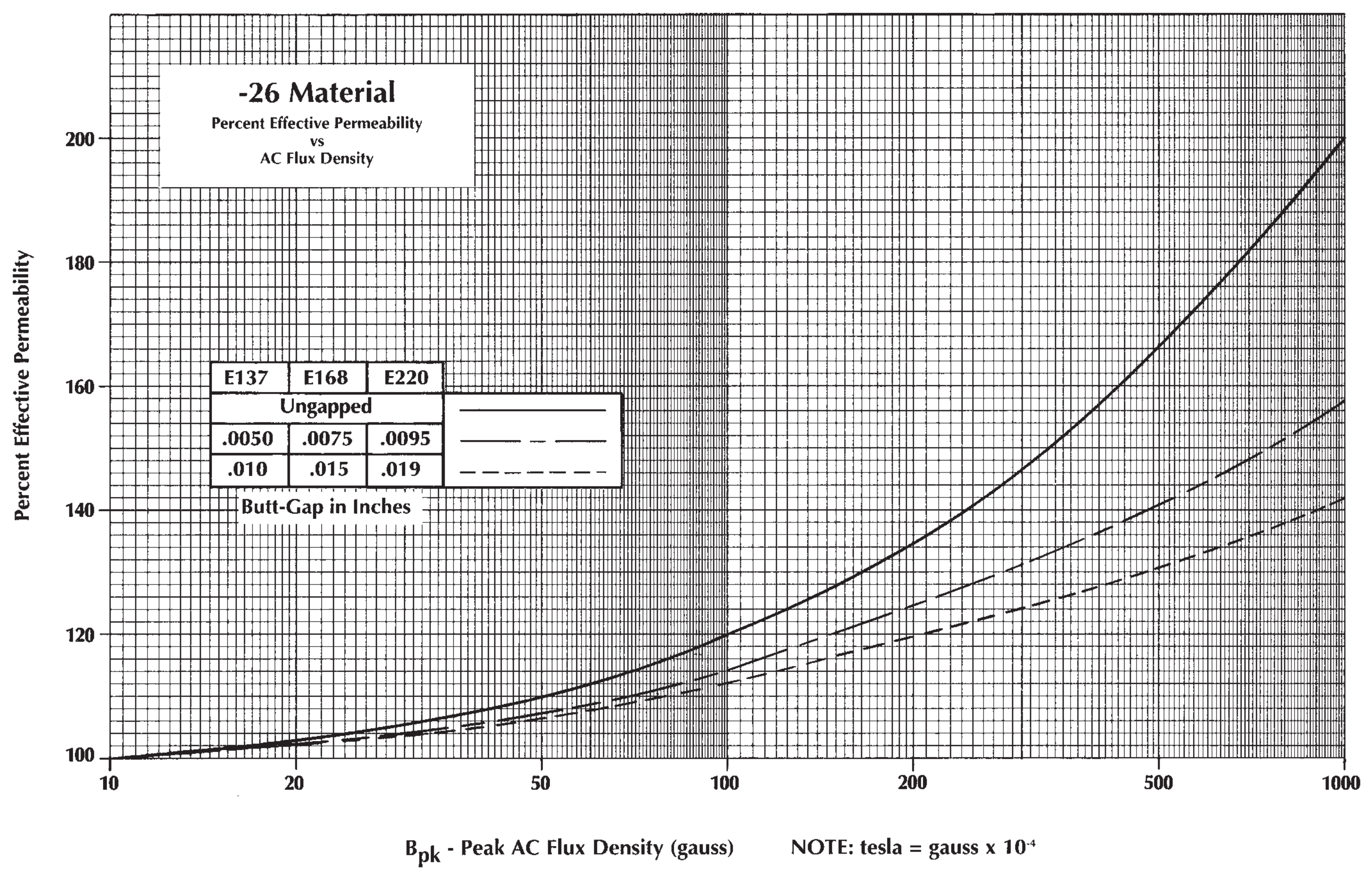
In addition to increasing energy storage, gapping also significantly reduces the swing of these materials with DC bias resulting in performance similar to -8, -18, -30, -34, and -35 Materials without a gap. Since -26, -40, and -52 Materials are less expensive than -8, -18, -30, -34 and -35 Materials this offers an attractive design alternative.

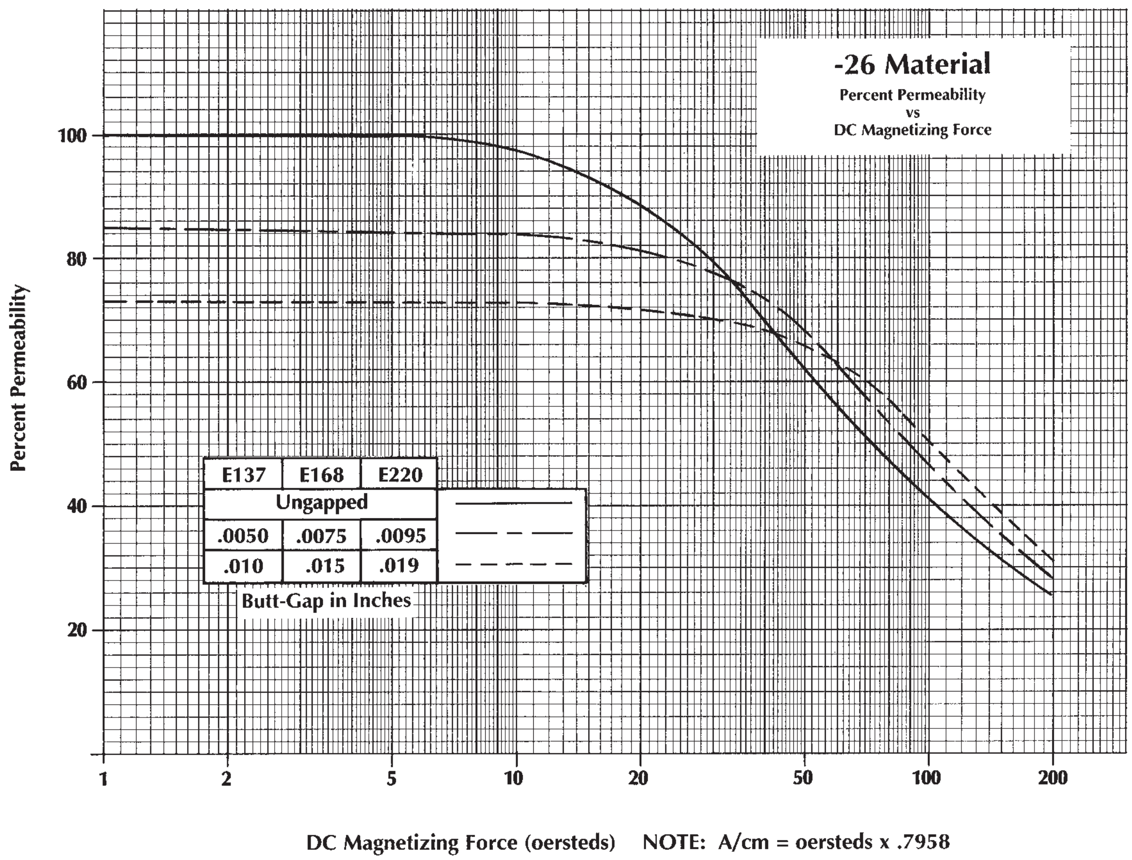
An additional discrete gap in iron powder does not have a dramatic impact on effective permeability as illustrated by the graph to the upper right. As a result, the gapping of iron powder E Cores is relatively non-critical when compared to ferrites and iron alloy lamitations.

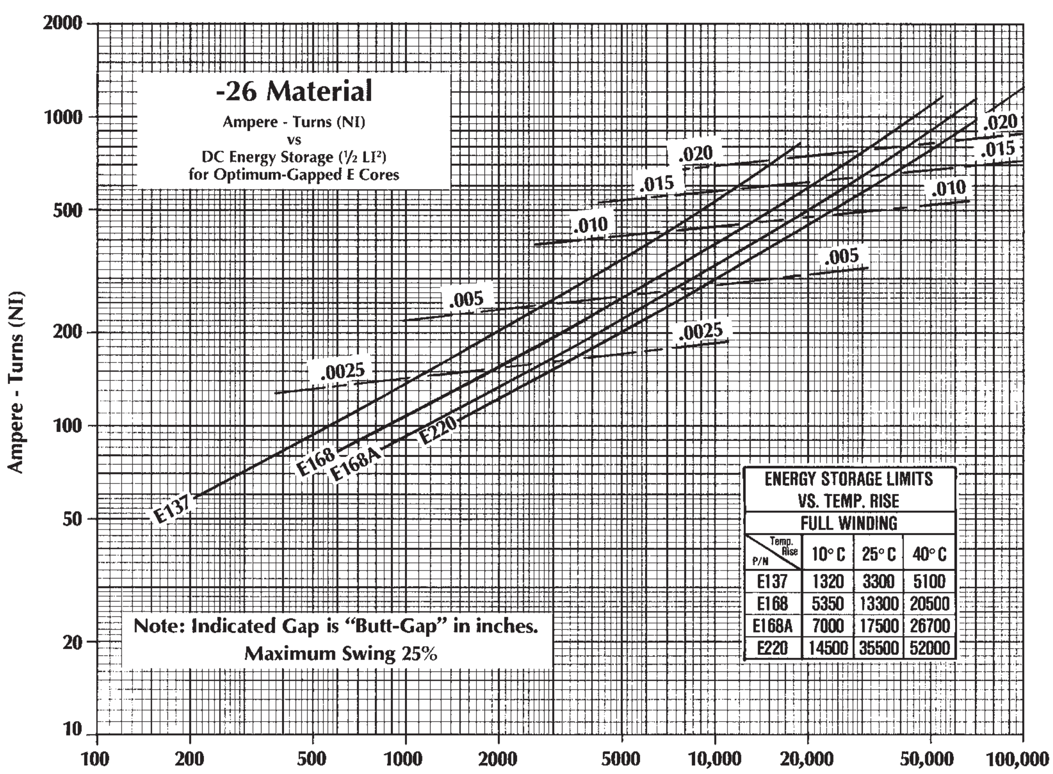
Energy Storage Curves for optimum butt-gapped E Cores in -26 Material are shown at the bottom of the following page. Similar or slightly higher energy storage will result with -52 Material while slightly lower energy storage will result for -40 Material with the same windings.

The term butt-gap has been used to indicate the physical separation of two standard E Cores (that are butted up against a spacer). By example, a set of cores with all three legs separated by .010 inches has a butt-gap of .010 inches. This creates an effective discrete gap of .020 inches. A butt-gap of .010 inches is equivalent to a total center-leg gap of .020 inches.

The E168, E168A, E220 and E305 size E Cores are available with standard center-leg gaps as detailed in the E Core listing on pages 15 - 18. The E168 and E168A are available with a center-leg gap of .015 inches per half. A set made up of two of these gapped cores will produce a center-leg gap of .030 inches. The E220 is available with a center-leg gap of .020 inches per half.







ENERGY STORAGE LIMITS VS. TEMP. RISE FULL WINDING

P/N \ Temp. Rise	10° C	25° C	40° C
E137	1320	3300	5100
E168	5350	13300	20500
E168A	7000	17500	26700
E220	14500	35500	52000

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DC APPLICATIONS

THE EFFECT OF AC OR RIPPLE ON DC INDUCTORS

The effect of AC or ripple flux can be significant in many DC inductor applications. The DC energy storage curves provided on pages 42-49 are based on a peak AC flux density of 10 gauss (1 mT) which will typically represent less than 1% ripple current. When significantly greater AC flux density is present, it becomes necessary to consider its effect on both core loss and permeability (inductance).

The interpretation of core loss in DC chokes is covered on pages 29-30. The core loss curves on pages 31-36 also include Et/N (volt-microsecond per turn) ratings for various core sizes at a number of frequencies for a 15Cº temperature rise due to core loss.

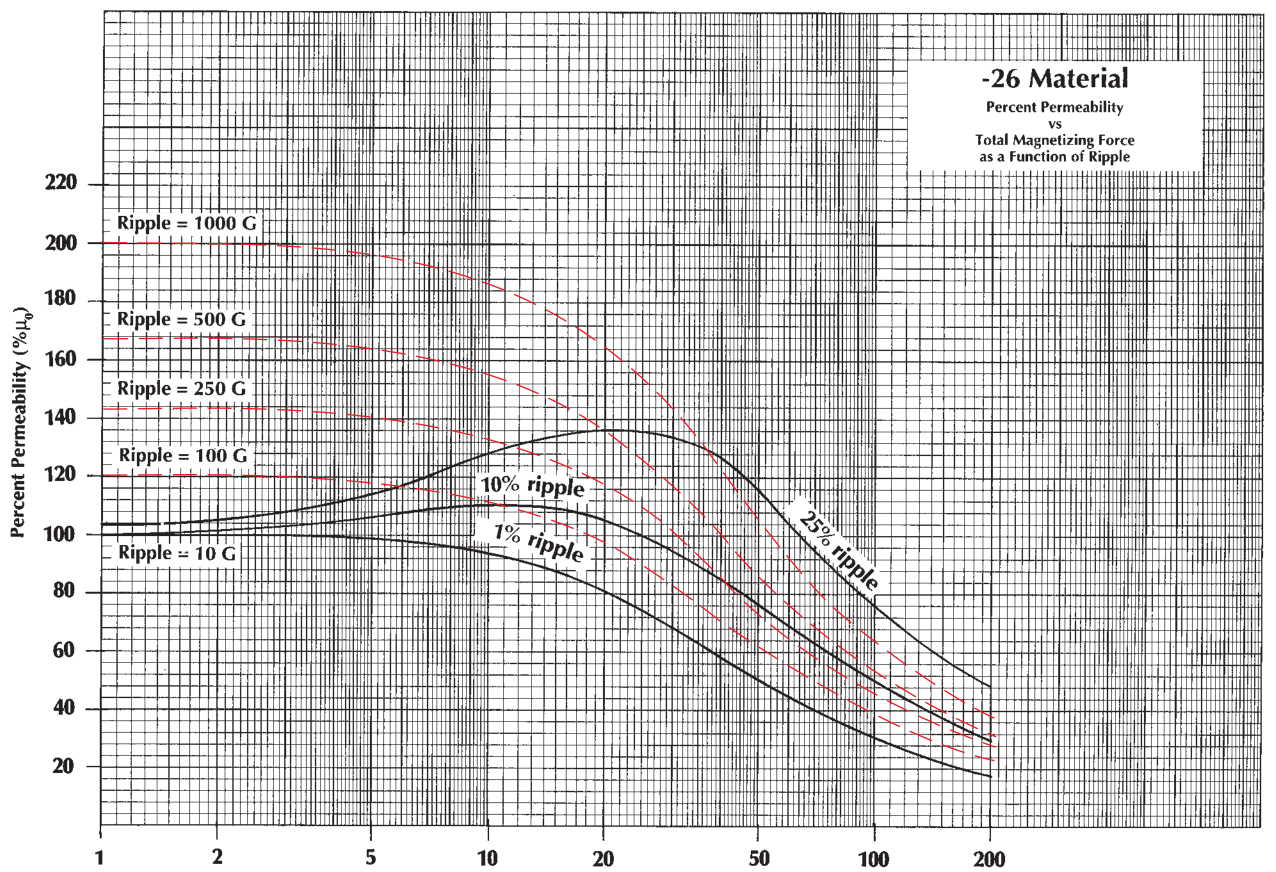
The -26 Material is a commonly used core material for DC output chokes. However, as switching frequencies increase, the lower core loss characteristics of -8, -18, and -52 Materials also make them good choices. The -8 Material will gain an additional advantage due to its lower permeability.

The temperature rise that will result from a given core loss per unit volume (mW/cm^3) is dependent on the core's effective surface area available to dissipate the heat. Since volume is a cubed function and surface area is a squared function, a core's capacity to dissipate heat per unit volume varies inversely with size. Large cores can dissipate less heat per unit volume than small cores for the same temperature rise. The winding tables on pages 64 and 65 contain information on surface area and power dissipation for temperature rises of 10Cº, 25Cº, and 40Cº.

Most DC output chokes operate with a peak AC flux density of less than 1000 gauss (100 mT); with a level of 200 gauss (20 mT) being more typical. The various iron powder material are affected by peak AC flux density as shown by the graph at the top of page 27. The percent initial permeability increases for all materials as the peak AC flux density is increased from 10 gauss (1 mT) to 1000 gauss (100 mT). The -26, -40, and -52 Materials have the most pronounced response to elevated AC flux density.

The -26 Material responds to the combined effects of AC and DC magnetization as shown by the graph below. The responses of -40 and -52 Materials are very similar.

Energy Storage Curves which take into account both the core loss and permeability characteristics for -26 Material with 10% and 25% ripple are provided on page 57. Fewer ampere-turns are required for the same energy storage than when <1% ripple is present. However, with high ripple at high frequency this material will be able to store less energy due to core loss limitations.



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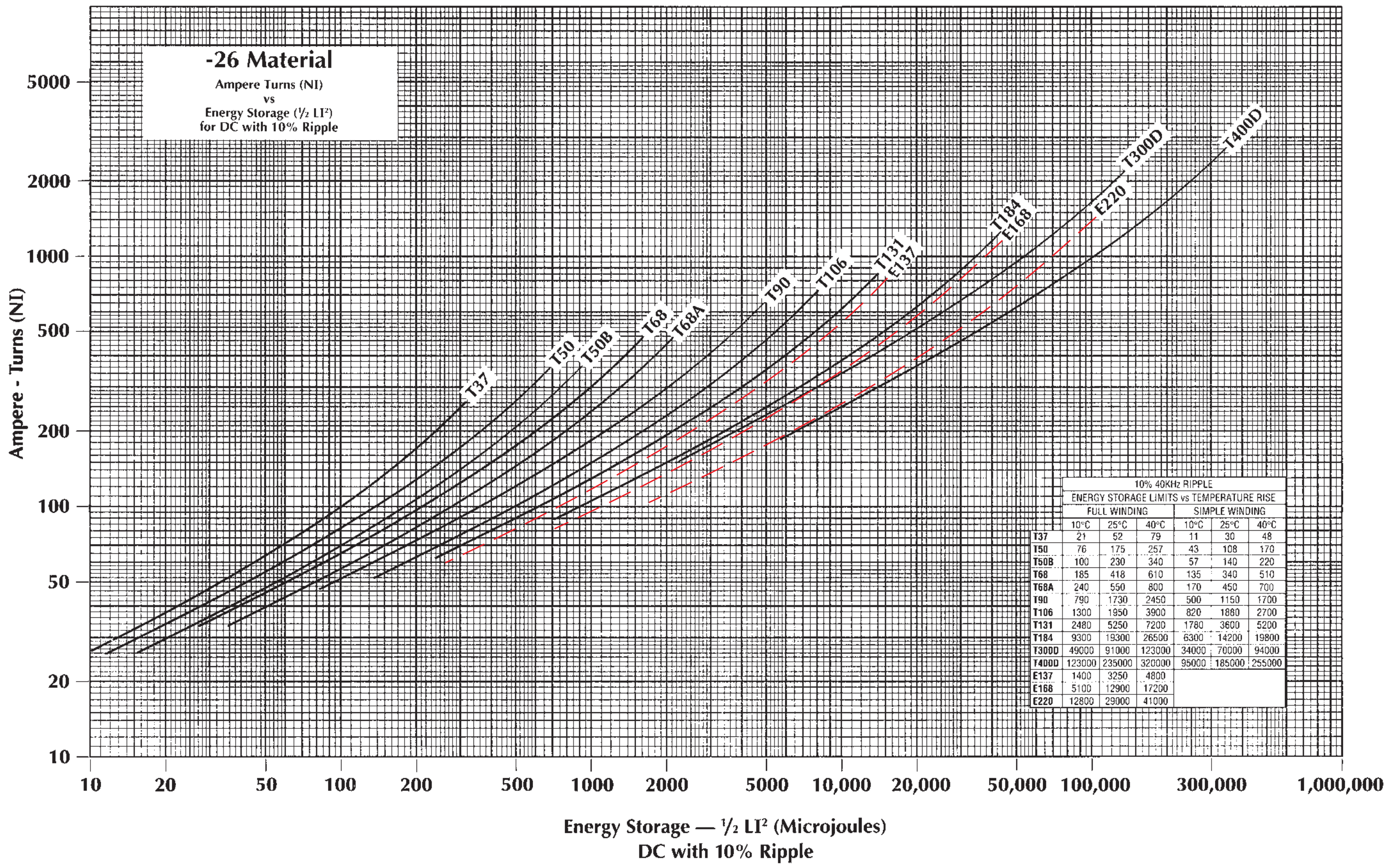
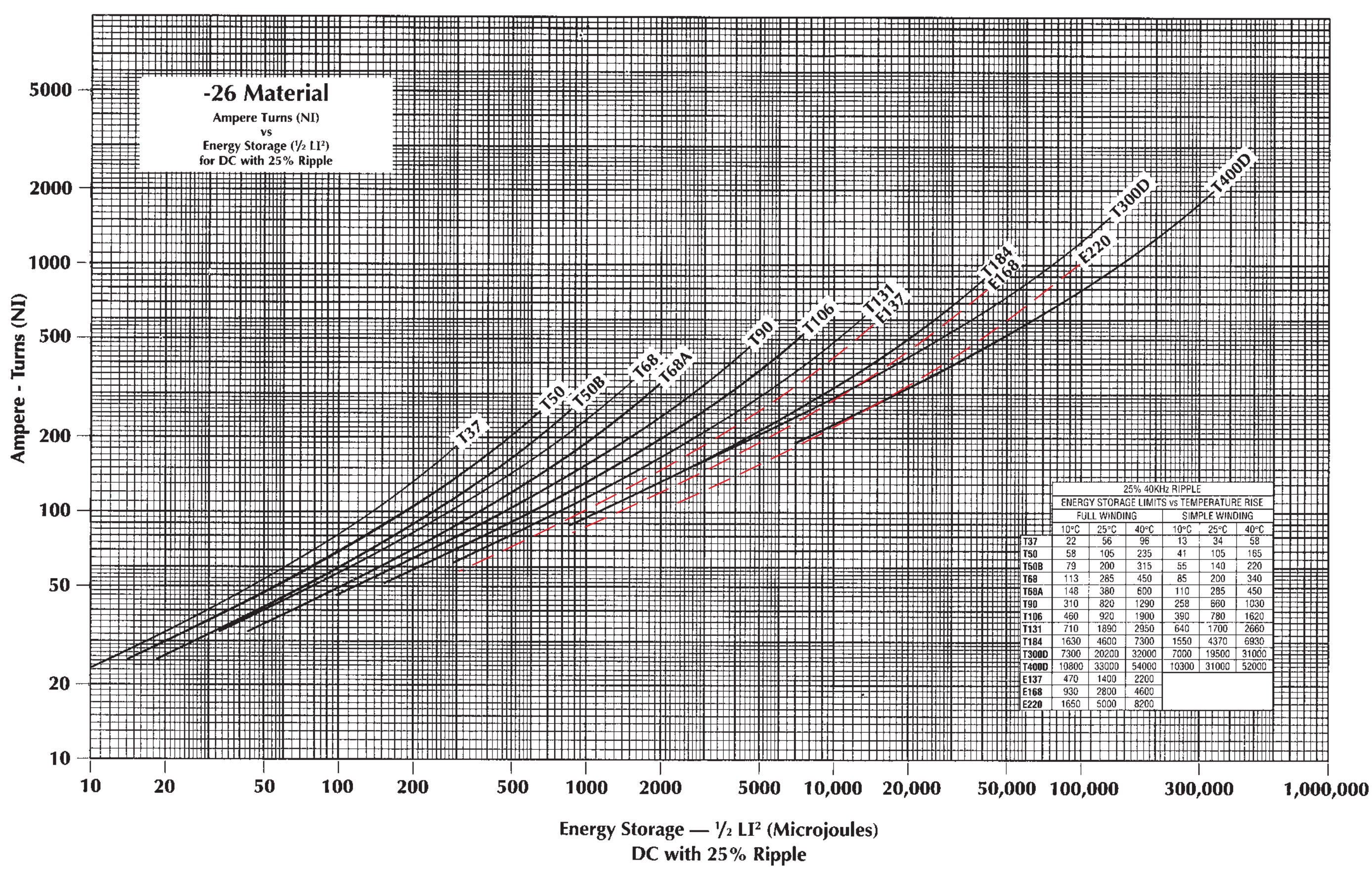


10% 40KHz RIPPLE						
ENERGY STORAGE LIMITS vs TEMPERATURE RISE						
	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T37	21	52	79	11	30	48
T50	76	175	257	43	108	170
T50B	100	230	340	57	140	220
T68	185	418	610	135	340	510
T68A	240	550	800	170	450	700
T90	790	1730	2450	500	1150	1700
T106	1300	1950	3900	820	1880	2700
T131	2480	5250	7200	1780	3600	5200
T184	9300	19300	26500	6300	14200	19800
T300D	49000	91000	123000	34000	70000	94000
T400D	123000	235000	320000	95000	185000	255000
E137	1400	3250	4800			
E168	5100	12900	17200			
E220	12800	29000	41000			



25% 40KHz RIPPLE						
ENERGY STORAGE LIMITS vs TEMPERATURE RISE						
	FULL WINDING			SIMPLE WINDING		
	10°C	25°C	40°C	10°C	25°C	40°C
T37	22	56	96	13	34	58
T50	58	105	235	41	105	165
T50B	79	200	315	55	140	220
T68	113	285	450	85	200	340
T68A	148	380	600	110	285	450
T90	310	820	1290	258	660	1030
T106	460	920	1900	390	780	1620
T131	710	1890	2950	640	1700	2660
T184	1630	4600	7300	1550	4370	6930
T300D	7300	20200	32000	7000	19500	31000
T400D	10800	33000	54000	10300	31000	52000
E137	470	1400	2200			
E168	930	2800	4600			
E220	1650	5000	8200			

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AC APPLICATIONS

POWER FACTOR BOOST PREREGULATOR CORE LOSS CALCULATIONS

The following article is a synopsis of an application note written by Bruce Carsten for Micrometals, Inc. followed by a section on PFC Design Guidelines written by Micrometals. The unabridged original version of the Bruce Carsten application note is available upon request.

The boost preregulator "front end" is increasingly used with AC line inputs to obtain an (essentially) Unity Power Factor, or UPF. Calculation of the core losses in the main inductor is problematic, however, as AC flux in changing continuously in a complex manner even with "fixed" input and output voltages.

The basic AC-DC boost preregulator power circuit is shown in Figure 1. The operation of this circuit is generally well known; the duty cycle of the main switch Q1 is controlled by logic (not shown) to boost the rectified line input voltage "Vi" to the output voltage "Vo", while forcing the short term average input current (=L1 current) to be proportional to the instantaneous AC line voltage. Since the AC line voltage is (ideally) sinusoidal, the line current is also sinusoidal.

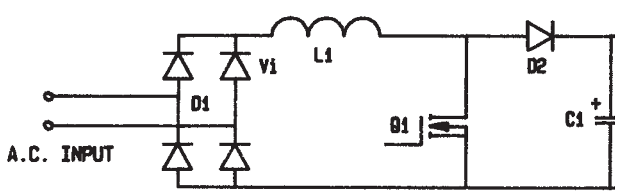

Figure 1

Basic Unity Power Factor boost preregulator power circuit

The actual control technique and circuit used are largely irrelevant to the calculation of losses in UPF boost preregulators. The loss calculation approach used here is generally applicable to constant switching frequency circuits where the boost inductor current is above "critical", or continuous, throughout most of the AC line cycle.

A sinusoidal input voltage, constant output voltage and constant conversion frequency are assumed for calculating the (relative) AC core and HF winding current losses in the main inductor (L1). The peak HF AC flux in the inductor core can be calculated from the switching voltage waveform. A convenient formula for peak AC flux "$\hat{B}$" in CGS units is:

$$\hat{B} = \frac{10^8 \, E \, \Delta T}{2 \, N \, A}$$

Where:
- E = Peak Inductor Voltage
- ΔT = Time Increment
- N = Number of Winding Turns
- A = Core Area (cm^2)

The maximum flux "$\hat{B}max$" occurs when:

$$Vi = Vo/2$$

Where:
- Vi = "Instantaneous" Input Voltage
- Vo = DC Output Voltage

The actual switching frequency AC flux varies over the AC line voltage half cycle. Curves of $\hat{B} / \hat{B}$ max vs. AC line phase angle θ, for various ratios of Vi/Vo (where Vi = Peak AC Input Voltage) are plotted in figure 2

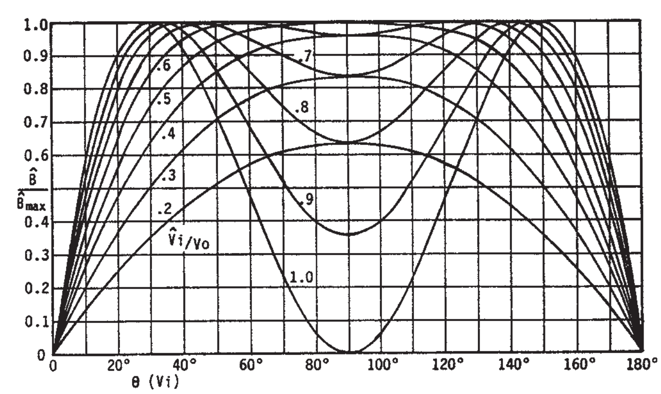

Figure 2

Relative Peak Flux in L1 Core vs. AC Input Voltage and Phase

At a constant switching frequency, the core loss "Pfe" will vary as $\hat{B}^n$, where the loss exponent "n" is typically between 1.65 and 3 for most magnetic materials, including powder iron materials. The ratio of average core loss (over an AC line voltage cycle) to the "maximum" loss (at Vi = Vo/2), for core loss exponents of 2.0, 2.5 and 3.0 are plotted in Figure 3.

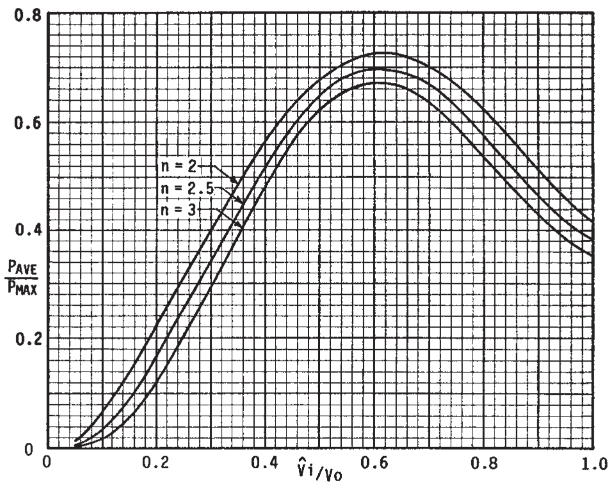

Figure 3

Ratio of Average to Maximum Core Loss vs. Vi/Vo and Loss Exponent "n"

It can be seen that the ratio of average/maximum core loss reaches a maxima when the peak AC line/DC output voltage ratio is near 0.61. The core loss ratio is not very sensitive to the core loss exponent, being somewhat less for higher loss exponents, with the largest average/maximum ratio only ranging from 0.672 for n = 3 to 0.725 for n = 2.

Since operation at the loss ratio maxima will occur in most UPF boost preregulators, a useful rule-of-thumb is that the "worst case" average core loss will be 70% of the loss calculated for Vi = Vo/2, where the Peak flux is:

$$\hat{B} = \frac{10^8 \ Vo}{8 \ N \ A \ f}$$

Where: f = Boost Switching Frequency

IRON POWDER PFC DESIGN GUIDELINES

Extra care must be taken when designing and specifying iron powder cores for PFC applications due to the AC content and complexity of the core loss calculations. Most present day applications for iron powder cores can have ambient temperatures up to 55C°. Therefore, the increase in temperature rise due to losses must be kept to a minimum.

It is important for a PFC design to be evaluated under the worst case conditions which will be at maximum power and in most designs when the peak input voltage is either at its lowest level or when the peak input voltage is .61 times the boost or output voltage. The worst case winding losses will occur at the lowest input voltage since this is when the maximum current will flow, but the worst case core losses will occur when the peak input voltage is .61 times the peak output voltage.

It is important to recognize that a PFC design dominated by core loss is not acceptable without first completing a thorough design analysis. It is generally recommended that the loss distribution be no greater than a 50/50% split between core and copper loss. In fact, a 20/80% or 25/75% split between core to copper loss is preferred. It is also important to remember that it is much easier to remove heat from the copper winding than from the core.

PFC applications mean that higher Peak AC Flux density conditions are often present in the core than traditional output choke applications. If an inappropriate core material or undersized core is selected, the core will be subjected to excessive high frequency core loss resulting in a temperature rise that can possibly lead to thermal failure.

Many designs today utilize variable speed fans in order to cool and "quiet down" the power supply. Even at a reduced power load condition, the effective AC flux density and resulting core loss of the PFC inductor can remain fairly constant. Only the copper loss (I^2R) has been reduced. Extreme care should be taken since a reduction in fan speed can result in a higher than expected temperature owing to the reduction of air flow.

The best way to determine the "hot spot" core temperature is to drill a small hole midway into the core and install a thermocouple wire. The soundness of the thermocouple connection to the core is critical for accurate results. Close attention should be paid to the "shadow" areas that do not get the benefit of good air flow. These areas will be at a higher temperature than those directly in the air flow path. It is recommended that the unit is operated continuously under the worst case conditions for a period of 4 to 8 hours or until the inductor reaches thermal equilibrium. The true maximum temperature of the core can then be determined. Iron Powder core materials do have differing thermal conductivities which will effect their temperature gradient. Please refer to the Thermal Conductivity information on page 3.

Selecting a lower permeability core material will reduce the peak operating flux density and associated core loss. This reduction in core loss can be very significant and will, generally, more than offset any increase in winding losses.

The Micrometals Design Software is also available for a rapid solution to your requirements.

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AC APPLICATIONS

IRON POWDER FOR 60Hz FILTER INDUCTORS

The addition of both U.S. and International regulations has increased the need to effectively filter the main power line. In order to accomplish this, both the common-mode and differential-mode (normal-mode) noise must be controlled. Common-mode noise is interference that is common to both the positive and neutral lines in relation to earth ground and is usually a result of capacitive coupling. Differential-mode noise is the interference that is present between the positive and neutral lines and is typically generated by switching devices such as transistors, SCRs and triacs. This type of noise is more readily filtered when the choke is in close proximity to the noise source.

Common-mode filtering requires capacitors to earth ground. Safety regulations limit these capacitors to a relatively low value. This mandated low value of capacitance for common-mode filtering makes a high value of inductance essential for effective filtering. Common-mode inductors typically require a minimum inductance of 1000 mH and are most often wound in a balun configuration on a 5000 or higher permeability ferrite core. The balun winding allows the 60 Hz flux density generated by each line to cancel in the core, thus avoiding saturation. Lower permeability materials like iron powder are useful for common-mode applications involving significant line imbalance. Otherwise, for most common-mode applications, the increased core size necessary to accommodate the number of turns needed to achieve the required inductance makes this alternative less attractive.

Differential-mode chokes usually have a single winding, though it is possible to put more than one differential-mode choke on a core by connecting the windings in the additive configuration rather than in the balun configuration. This type of choke must be able to support significant 60 Hz flux density without saturating and at the same time respond to the high frequency noise. The distributed air-gap of iron powder in addition to its high saturation flux density of greater than 12,000 gauss (1.2 T) make it well-suited for this requirement.

Iron powder experiences magnetostriction. This means that as the material is magnetized it experiences a very slight change in dimensions. In applications above audible frequencies (>20 kHz) this is of no concern. In certain 60 Hz applications, however, core buzzing can be noticeable. This condition will be more noticeable with E Cores than with toroids. It wil also be more significant with signals which have been chopped (light dimmers, motor controllers) than with normal sinewaves. It is also dependent on operating AC flux density.

Energy storage inductor design is limited by temperature rise resulting from the combined copper and core loss, and core saturation. While the -8, -18 and -52 Materials have lower core losses at 60 Hz.

Further, the higher core loss characteristics of the -26 and -40 Materials at frequencies above 25 KHz will produce a coil with low Q at high frequency. This characteristic is an additional benefit in helping to suppress the unwanted signals. (see pages 27-33).

The -26 and -40 Materials maintain good permeability versus AC flux density characteristics as illlustrated at the top of page 27. The significant increase in percent permeability for these materials can be a considerable advantage. It appears that this increase in permeability is experienced in applications such as light dimmers.

Tests performed with a low-level 10 KHz sinewave superimposed over a 60 Hz signal of increasing level did indicate that the high frequency signal experienced an increase in inductance as the 60 Hz signal was increased. While this may be the case for a contiuous time averaged signal, it is not clear if this is the case for instantaneous noise signals.

Energy Storage Curves for 60 Hz filtering applications for -26 and -40 Materials are shown on page 61. These curves take into account the increase in permeability illustrated by the curves at the top of page 27. The AC flux density levels have been referenced. These flux density references can be useful in approximating core loss as well as determining how the inductance will bary with current.

The representation of percent permeability versus peak AC flux density at the top of page 27 shows how the permeability (inductance) will change with voltage across the coil, but it does not provide a clear view of how the inductance will vary with current. The graphs at the top of page 62 are an attempt to illustrate (in relative terms only) how the relative inductance will change with changes in current.

Energy stroage limits for temperature rises of 10Cº, 25Cº and 40 Cº are also listed for 60 Hz applications for a number of different core sizes. For the same temperature rises, all core sizes operate at a similar flux density, but the loss distribution differs. With physically large cores, the majority of the loss is due to the core losses, while with the physically small cores the majority of the loss is due to the losses in winding. This phenomenon is not unique to iron powder.

A design example can be found at the bottom of page 62. In addition, an inductance reference table is included on page 63.

For applications where it is unclear if the high frequency signal will experience the same increase in permeability as the 60 Hz signal, it is recommended that the 60 Hz signal be treated as DC current. This will produce a significantly different result but will be the most conservative approach.

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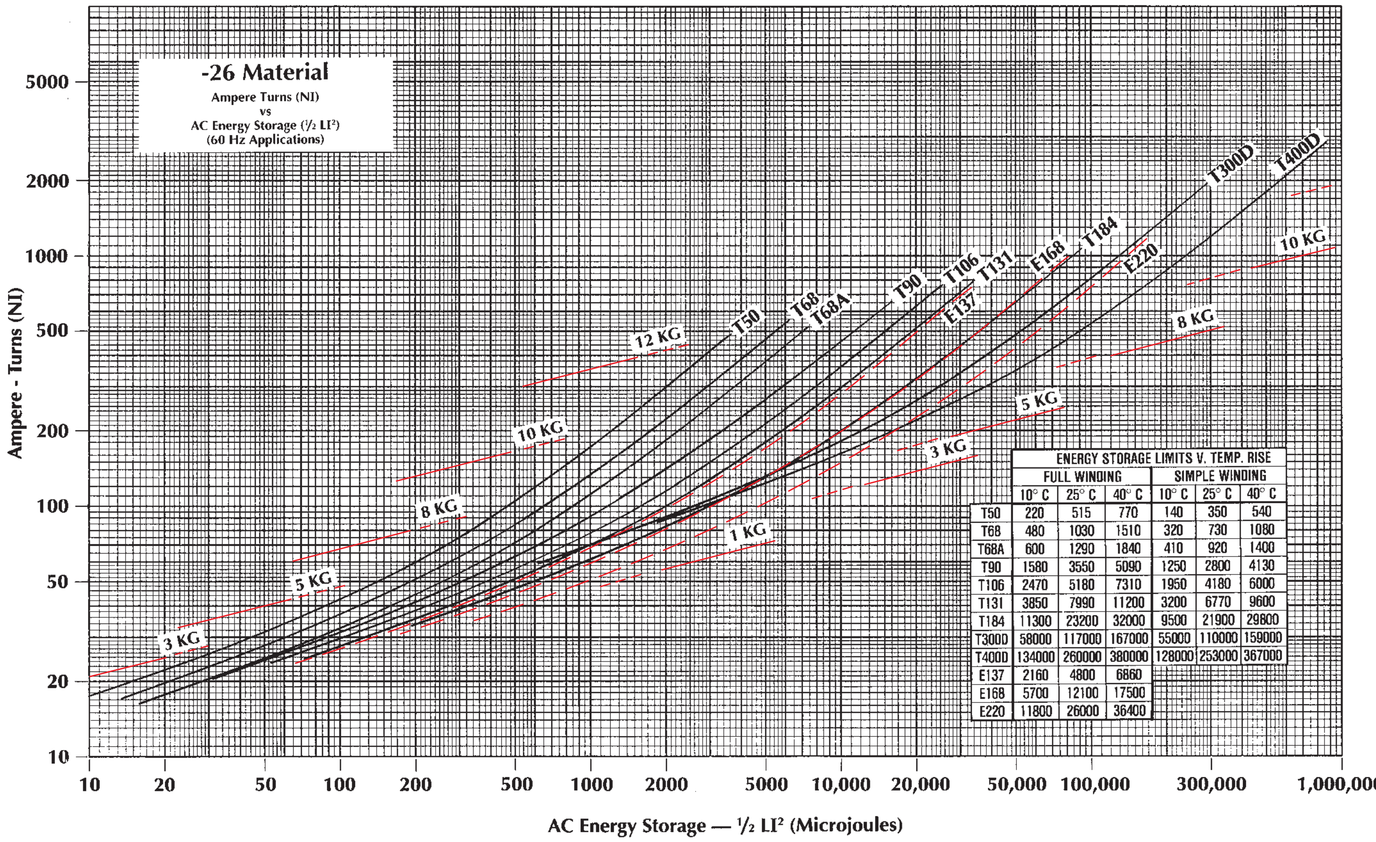
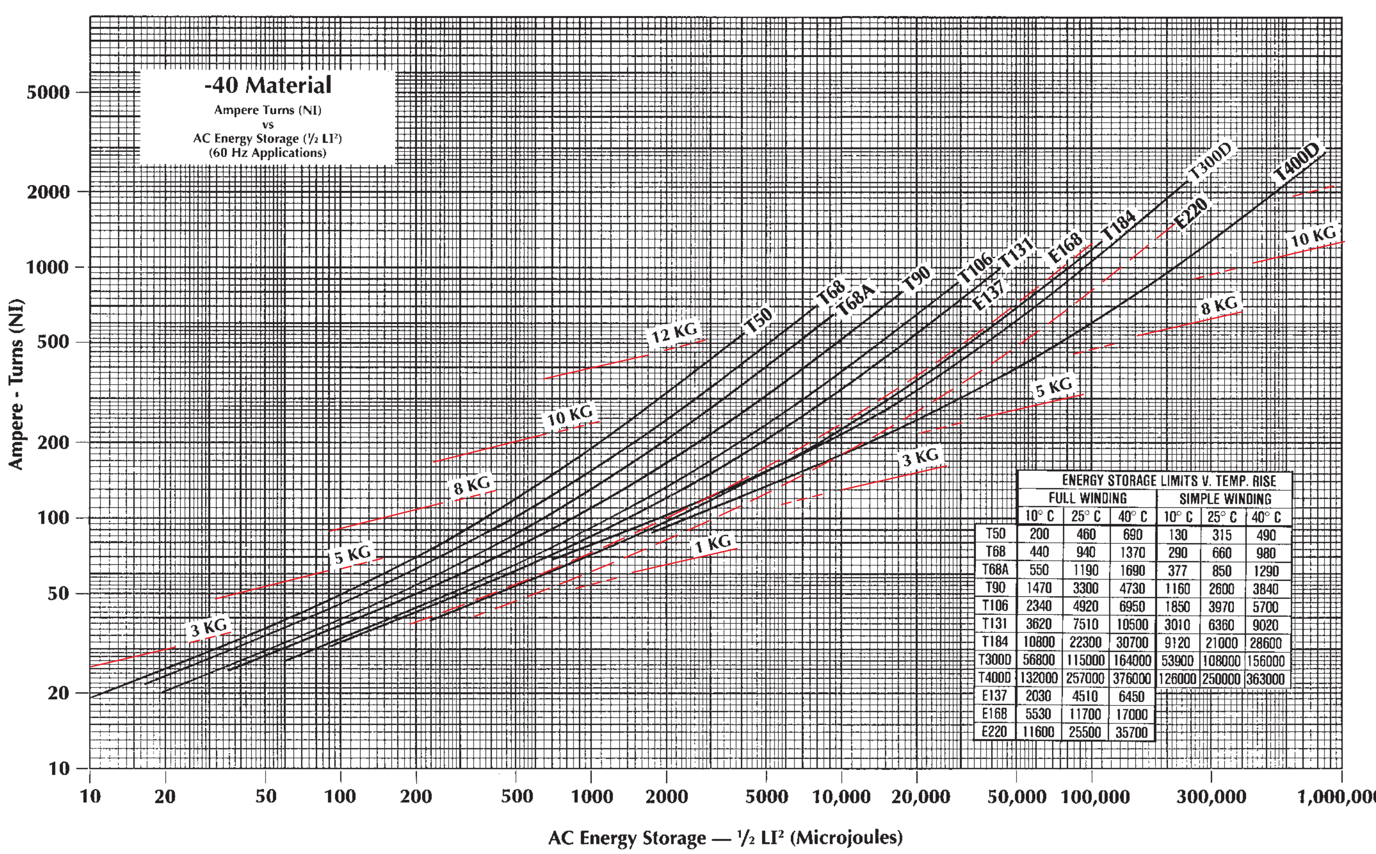


ENERGY STORAGE LIMITS V. TEMP. RISE	FULL WINDING			SIMPLE WINDING		
	10° C	25° C	40° C	10° C	25° C	40° C
T50	220	515	770	140	350	540
T68	480	1030	1510	320	730	1080
T68A	600	1290	1840	410	920	1400
T90	1580	3550	5090	1250	2800	4130
T106	2470	5180	7310	1950	4180	6000
T131	3850	7990	11200	3200	6770	9600
T184	11300	23200	32000	9500	21900	29800
T300D	58000	117000	167000	55000	110000	159000
T400D	134000	260000	380000	128000	253000	367000
E137	2160	4800	6860			
E168	5700	12100	17500			
E220	11800	26000	36400			



ENERGY STORAGE LIMITS V. TEMP. RISE	FULL WINDING			SIMPLE WINDING		
	10° C	25° C	40° C	10° C	25° C	40° C
T50	200	460	690	130	315	490
T68	440	940	1370	290	660	980
T68A	550	1190	1690	377	850	1290
T90	1470	3300	4730	1160	2600	3840
T106	2340	4920	6950	1850	3970	5700
T131	3620	7510	10500	3010	6360	9020
T184	10800	22300	30700	9120	21000	28600
T300D	56800	115000	164000	53900	108000	156000
T400D	132000	257000	376000	126000	250000	363000
E137	2030	4510	6450			
E168	5530	11700	17000			
E220	11600	25500	35700			

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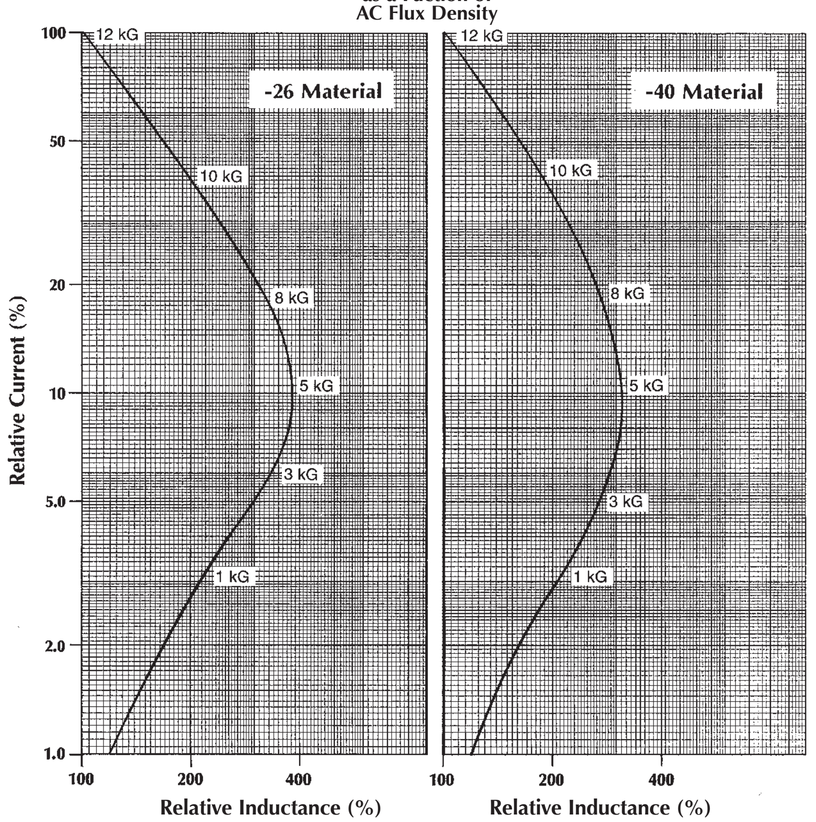
Relative
Current vs Inductance
as a Fuction of
AC Flux Density



60 Hz INDUCTOR DESIGN

Requirements: 500 µH minimum from 1 to 5 amps of 60 Hz Current.

Consider minimum current level.

For this example, the inductor must maintain 500µH minimum from 1 to 5 amperes, or down to 20% of full-rated current (I max). The importance of this consideration is illustrated by the graph above. This shows that, in the case of -40 Material, if the inductor is designed to operate at 10 kG at I max, that the inductance will be greater than or equal to L at I max down to 2.5 ÷ 42 = 6.0% of I max. Likewise, if the inductor operates at 8 kG at I max, the inductor can only be operated down to 4.6 ÷ 19.5 = 25% of I max before lower inductance will result.

Calculate Energy Storage Required ($^1/_2$ LI^2)

$^1/_2$ LI^2 = ($^1/_2$) (500) (5^2) = 6250 µJ

Select appropriate core size.

In this example -40 Material will be used. In order to maintain a minimum inductance down to 1 amp (20% of I max), the inductor must be designed to operate at greater than 8 kG at I max. This requires a core no larger than the E137 core or T131 toroidal core. To keep temperature rise down, the T131 will be selected.

Determine number of turns.

At 6250 µJ, the T131-40 indicates 235 ampere-turns.

NI = 235 N = 235 / 5 = 47 turns

Select wire size.

Since the "simple" winding results are a rough approximation of typical single-layer windings, the Single Layer Winding table on page 64 can be used as a guide in selecting the wire size. #19 will fit in a single layer and yield about 20C° temperature rise due to the winding losses.

Solution: Part no. T131-40
47 turns #19

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60 Hz Inductor Examples

Note: If the inductors are operated to at least 15% of full-rated current, the inductance will be greater than or equal to te value listed

TOROIDAL CORES: SINGLE LAYER WINDINGS (approximate)

PART # / 60Hz current / WIRE * SIZE	1.0 amps #28 AWG	2.5 amps #24 AWG	5.0 amps #20 AWG	7.5 amps #18 AWG	10 amps #15 AWG	15 amps #13 AWG	20 amps #11 AWG	30 amps #9 AWG
T50-26	460 µH *63 turns*	136 µH *47 turns*	40.8 µH *21 turns*	22.0 µH *16 turns*	8.2 µH *9 turns*	3.6 µH *6 turns*	2.4 µH *5 turns*	0.9 µH *3 turns*
T68-26A	1,200 µH *79 turns*	352 µH *47 turns*	113 µH *28 turns*	47.3 µH *18 turns*	25.6 µH *13 turns*	11.8 µH *15 turns*	5.6 µH *11 turns*	3.5 µH *7 turns*
T90-26	3,100 µH *120 turns*	960 µH *74 turns*	308 µH *44 turns*	140 µH *30 truns*	77.0 µH *22 turns*	35.1 µH *15 turns*	19.3 µH *11 turns*	8.0 µH *8 turns*
T106-26	4,600 µH *125 turns*	1,140 µH *77 turns*	452 µH *46 turns*	213 µH *32 turns*	120 µH *24 turns*	53.3 µH *16 turns*	30.0 µH *12 turns*	13.3 µH *8 turns*
T131-26	7,100 µH *141 turns*	2,140 µH *87 truns*	704 µH *53 turns*	331 µH *37 turns*	180 µH *27 turns*	80.0 µH *18 turns*	46.5 µH *14 turns*	20.0 µH *9 turns*
T157-26	13,600 µH *213 turns*	4,000 µH *132 turns*	1,340 µH *82 turns*	729 µH *64 turns*	370 µH *44 turns*	198 µH *34 turns*	180 µH *25 turns*	56.7 µH *19 turns*
T184-26	22, 400 µH *213 turns*	6,720 µH *132 turns*	2,240 µH *82 turns*	1,050 µH *57 turns*	590 µH *43 turns*	258 µH *28 turns*	140 µH *21 turns*	64.4 µH *14 turns*
T300-26D	88,000 µH *435 turns*	25,900 µH *272 turns*	8,560 µH *169 turns*	4,730 µH *135 turns*	2,420 µH *93 turns*	1,290 µH *72 turns*	760 µH *56 turns*	344 µH *38 turns*
T400-26D	180,000 µH *507 turns*	57,600 µH *317 turns*	19,200 µH *197 turns*	10,700 µH *157 turns*	5,400 µH *108 turns*	2,840 µH *83 turns*	1,700 µH *65 turns*	811 µH *46 turns*

E CORES: FULL BOBBIN WINDINGS

PART # / 60Hz current / WIRE * SIZE	1.0 amps #23 AWG	2.5 amps #19 AWG	5.0 amps #16 AWG	7.5 amps #15 AWG	10 amps #13 AWG	15 amps #12 AWG	20 amps #11 AWG	30 amps #10 AWG
E137-26	13,600 µH *217 turns*	2,180 µH *87 turns*	544 µH *43 turns*	241 µH *29 turns*	132 µH *21 turns*	64.0 µH *15 turns*	31.0 µH *10 turns*	14.7 µH *7 turns*
E168-26	34,600 µH *295 turns*	5,540 µH *118 turns*	1,380 µH *59 turns*	615 µH *39 turns*	356 µH *30 turns*	147 µH *19 turns*	80.0 µH *14 turns*	34.0 µH *9 turns*
E220-26	73,000 µH *350 turns*	11,700 µH *140 turns*	2,920 µH *70 turns*	1,300 µH *47 turns*	730 µH *35 turns*	320 µH *23 turns*	175 µH *17 turns*	74.4 µH *11 turns*

* Based on max temperature rise of 40C° due to copper and core loss

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WINDING TABLE

SINGLE LAYER WINDING TABLE

WIRE SIZE (AWG)			28	26	24	22	20	19	18	17	16	15	14	13	12	11	10	TOTAL POWER DISSIPATION (WATTS) VS TEMP. RISE		
RESISTIVITY (mΩ/cm)			2.13	1.34	.842	.530	.330	.264	.210	.166	.132	.104	.0828	.0651	.0521	.0413	.0328			
MAXIMUM AMPS 10C°			.64	.90	1.29	1.83	2.62	3.12	3.72	4.45	5.33	6.35	7.60	9.03	10.8	12.9	15.4			
PER ALLOWABLE 25C°			1.07	1.52	2.17	3.09	4.41	5.26	6.27	7.50	8.97	10.7	12.8	15.2	18.2	21.7	26.0			
TEMP RISE 40C°			1.38	1.97	2.81	4.00	5.70	6.81	8.11	9.70	11.6	13.8	16.6	19.7	23.5	28.1	33.6			
PART No.	**MLT cm/turn**	**Surface Area cm^2**	**NUMBER OF TURNS**															**10C°**	**25C°**	**40C°**
T16	.80	.80	9	6	4	2	1											.013	.038	.067
T20	.96	1.16	11	8	5	3	2	1										.018	.055	.097
T25	1.19	1.88	18	14	10	7	5	4	3	2	1							.030	.089	.157
T26	1.74	2.67	15	11	8	5	3	2	1									.042	.127	.223
T30	1.44	2.79	25	20	15	11	7	6	5	4	3	2	1	1				.044	.133	.233
T37	1.53	3.77	37	29	22	17	12	11	9	7	6	5	4	3	2	1	1	.060	.180	.316
T38	1.92	4.43	31	24	18	13	10	8	7	5	4	3	2	2	1			.071	.211	.371
T44	1.84	5.23	43	34	26	20	15	13	11	9	7	6	5	4	3	2	1	.083	.249	.437
T50	2.01	6.86	59	47	37	28	22	19	16	14	12	10	8	7	6	4	3	.109	.326	.574
T50B	2.32	7.83	59	47	37	28	22	19	16	14	12	10	8	7	6	4	3	.125	.373	.659
T50D	2.95	9.87	59	47	37	28	22	19	16	14	12	10	8	7	6	4	3	.157	.470	.826
T51C	2.58	7.56	36	28	22	16	12	10	9	7	6	5	4	3	2	1		.120	.360	.633
T60	2.48	9.84	67	53	41	32	25	21	19	16	14	12	10	8	7	6	4	.156	.468	.824
T60D	3.68	14.3	67	53	41	32	25	21	19	16	14	12	10	8	7	6	4	.228	.681	1.20
T68	2.47	11.2	74	59	46	36	28	24	21	18	16	14	12	10	8	7	5	.178	.533	.936
T68A	2.77	12.5	74	59	46	36	28	24	21	18	16	14	12	10	8	7	5	.198	.594	1.04
T68D	3.41	15.2	74	59	46	36	28	24	21	18	16	14	12	10	8	7	5	.241	.722	1.27
T72	3.15	13.3	54	43	33	26	19	17	14	12	11	9	7	6	5	4	3	.212	.634	1.11
T80	2.8	15.5	103	82	64	51	39	35	30	27	23	20	17	15	13	11	9	.246	.736	1.30
T80B	3.44	18.7	103	82	64	51	39	35	30	27	23	20	17	15	13	11	9	.298	.892	1.57
T80D	4.07	22.0	103	82	64	51	39	35	30	27	23	20	17	15	13	11	9	.350	1.05	1.84
T90	3.64	22.4	115	92	72	57	44	39	34	30	26	23	20	17	15	13	11	.356	1.07	1.88
T94	3.44	22.0	117	94	74	58	45	40	35	31	27	24	21	18	15	13	11	.350	1.05	1.85
T106	4.49	31.0	118	95	74	59	46	40	36	31	27	24	21	18	15	13	11	.492	1.47	2.59
T106A	3.86	25.8	118	95	74	59	46	40	36	31	27	24	21	18	15	13	11	.427	1.28	2.25
T106B	5.19	35.5	118	95	74	59	46	40	36	31	27	24	21	18	15	13	11	.565	1.69	2.97
T124	3.95	33.3	150	120	95	75	59	52	46	40	36	31	27	24	21	18	15	.529	1.58	2.79
T130	4.75	42.2	165	133	105	83	65	58	51	45	40	35	31	27	23	20	17	.671	2.01	3.53
T130A	3.67	33.2	165	133	105	83	65	58	51	45	40	35	31	27	23	20	17	.529	1.58	2.78
T131	5.11	42.1	134	107	85	67	52	46	41	36	32	28	24	21	18	16	13	.669	2.00	3.52
T132	4.95	42.2	147	118	93	74	58	51	45	40	35	31	27	23	20	18	15	.671	2.01	3.53
T141	4.75	46.8	188	151	119	95	75	66	59	52	46	40	35	31	27	24	20	.744	2.23	3.92
T150	5.28	53.2	180	145	114	91	71	63	56	49	44	38	34	29	26	22	19	.846	2.53	4.45
T157	5.89	63.2	204	164	129	103	81	72	64	56	50	44	39	34	30	26	23	1.01	3.01	5.29
T175	6.58	79.1	230	186	147	117	92	82	73	64	57	50	44	39	34	30	26	1.26	3.76	6.16
T184	7.54	89.2	202	163	129	102	81	72	63	56	50	44	38	34	29	26	22	1.42	4.25	7.47
T200	6.50	90.9	270	217	172	137	108	96	86	76	67	60	53	46	41	36	31	1.45	4.33	7.61
T200B	8.78	120	270	217	172	137	108	96	86	76	67	60	53	46	41	36	31	1.91	5.74	10.1
T201	8.90	111	202	163	129	102	81	72	63	56	50	44	38	34	29	26	22	1.76	5.28	9.28
T225	6.93	109	305	245	195	155	123	109	97	86	78	68	60	53	48	41	36	1.74	5.21	9.16
T225B	9.21	143	305	245	195	155	123	109	97	86	78	68	60	53	48	41	36	2.27	6.79	11.9
T250	10.4	166	270	217	172	137	108	96	86	76	67	60	53	46	41	36	31	2.63	7.88	13.9
T300	7.95	173	422	341	271	216	171	153	136	121	108	96	85	75	66	58	52	2.75	8.23	14.5
T300D	10.5	223	422	341	271	216	171	153	136	121	108	96	85	75	66	58	52	3.55	10.6	18.7
T400	11.1	301	494	399	317	254	201	179	160	142	126	113	100	88	78	69	61	4.79	14.3	25.3
T400D	14.4	384	494	399	317	254	201	179	160	142	126	113	100	88	78	69	61	6.10	18.2	32.1
T520	13.7	496	680	550	437	350	278	248	221	197	176	156	139	123	109	97	86	7.88	23.6	41.5
T520D	17.7	629	680	550	437	350	278	248	221	197	176	156	139	123	109	97	86	10.0	30.0	52.7
T650	23.1	986	789	621	494	396	315	281	250	223	199	177	158	139	124	110	98	15.7	46.9	82.5

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"FULL WINDING" TABLE (45% TOROID ID REMAINING)

WIRE SIZE (AWG)			28	26	24	22	20	19	18	17	16	15	14	13	12	11	10	AMPERE TURNS VS. TEMP RISE DUE TO COPPER LOSS			TOTAL POWER DISSIPATION (WATTS) VS. TEMP.RISE		
RESISTIVITY (mΩ/cm)			2.13	1.34	.842	.530	.330	.264	.210	.166	.132	.104	.0828	.0651	.0521	.0413	.0328						
PART No.	MLT cm/turn	Surface Area cm^2	NUMBER OF TURNS															10C°	25C°	40C°	10C°	25C°	40C°
16	.80	.80	13	8	5	3	2	1	1	1								10	17	23	.013	.038	.067
T20	.96	1.16	16	6	4	2	2	1	1	1	1							12	21	29	.018	.055	.097
T25	1.19	1.88	30	20	12	8	5	4	3	2	2	1	1	1				19	34	45	.030	.089	.157
T26	1.74	2.67	23	15	9	6	4	3	2	2	1	1	1					16	29	39	.042	.127	.223
T30	1.44	2.79	48	32	20	13	8	6	5	4	3	2	2	1	1	1		27	47	62	.044	.133	.233
T37	1.53	3.77	90	59	37	24	15	12	9	7	6	5	4	3	2	2	1	42	72	96	.060	.180	.316
T38	1.92	4.43	65	43	27	17	11	9	7	5	4	3	2	2	1	1	1	34	60	79	.071	.211	.371
T44	1.84	5.23	112	73	46	30	19	15	12	9	7	6	5	3	3	2	2	50	87	110	.083	.249	.437
T50	2.01	6.86	196	128	81	52	33	26	21	17	13	10	8	6	5	4	3	73	120	160	.109	.326	.574
T51C	2.58	7.56	85	56	35	23	14	11	9	7	6	4	3	3	2	1	1	44	77	100	.120	.360	.633
T60	2.48	9.84	241	158	100	65	41	33	26	21	16	13	10	8	6	5	4	87	150	200	.156	.468	.824
T68	2.47	11.2	293	192	122	78	50	40	32	25	20	16	13	10	8	6	5	100	170	230	.178	.533	.936
T72	3.15	13.3	168	110	69	45	28	22	18	14	11	9	7	5	4	3	3	75	130	170	.212	.634	1.11
T80	2.80	15.5	525	343	218	141	89	71	57	45	36	29	23	18	14	11	9	150	260	340	.246	.736	1.30
T90	3.64	22.4	648	424	269	174	110	88	70	56	45	36	28	22	18	14	11	170	300	400	.356	1.07	1.88
T94	3.44	22.0	672	440	279	180	114	91	73	58	46	37	29	23	18	14	11	180	320	420	.350	1.05	1.85
T106	4.49	31.0	696	455	289	187	118	95	75	60	48	38	20	24	19	15	12	190	330	440	.492	1.47	2.59
T124	3.95	33.3	1080	707	449	290	184	147	117	93	75	60	47	37	30	23	19	260	460	601	.529	1.58	2.79
T130	4.75	42.2	1301	853	542	350	222	177	142	113	90	72	57	45	36	28	23	300	520	690	.671	2.01	3.53
T131	5.11	42.1	877	574	365	236	149	119	95	78	61	48	38	30	24	19	15	240	410	550	.669	2.00	3.52
T132	4.95	42.2	1050	687	437	282	179	143	114	91	73	58	46	36	29	23	18	260	460	610	.671	2.01	3.53
T141	4.75	46.8	1659	1086	690	446	283	226	180	144	115	92	73	57	46	36	29	360	620	820	.744	2.23	3.92
T10	5.28	53.2	1530	1002	636	411	261	208	168	132	106	85	67	53	42	33	27	350	600	800	.846	2.53	4.45
T157	5.89	63.2	1933	1266	805	520	329	263	210	168	134	107	85	67	53	42	34	400	700	930	1.01	3.01	5.29
T175	6.58	79.1	2453	1606	1021	659	418	334	267	213	170	136	108	85	68	54	43	480	830	1110	1.26	3.76	6.16
T184	7.54	89.2	1933	1266	805	520	329	263	210	168	134	107	85	67	53	42	34	420	730	970	1.42	4.25	7.47
T200	6.50	90.9	3348	2192	1393	933	571	456	365	290	232	186	148	116	93	74	59	610	1050	1400	1.45	4.33	7.61
T201	8.90	111	1933	1266	805	520	329	263	210	168	134	107	85	87	53	42	34	430	750	1000	1.76	5.28	9.28
T225	6.93	109	4230	2770	1760	1137	721	277	461	367	294	235	186	147	117	92	74	720	1260	1670	1.74	5.21	9.16
T250	10.4	166	3348	2192	1393	900	571	456	365	290	232	186	148	116	93	74	59	650	1120	1490	2.63	7.88	13.9
T300	7.95	173	7981	5227	3322	2146	1361	1089	870	693	554	443	352	278	221	176	140	1170	2030	2690	2.75	8.23	14.5
T400	11.1	301	10.8K	7104	4515	2916	1850	1480	1182	942	754	602	479	378	301	240	191	1530	2650	3510	4.79	14.3	25.2
T520	13.7	496	20.3K	13.3K	8461	5465	3467	2773	2261	1765	1413	1129	868	708	564	450	350	2420	4180	5550	7.88	23.6	41.5
T650	23.1	986	26.2K	17.2K	10.9K	7057	4477	3581	2861	2280	1824	1458	1159	914	729	581	463	2980	5170	6850	15.7	46.9	82.5
E CORES																							
E49	2.54	5.09	96	48	30	21	12	10	8	4	3	3	2	2	1	0	0	41	72	96	.081	.242	.426
E75	3.81	11.2	250	160	96	60	40	24	21	18	12	10	8	4	3	3	2	74	120	170	.178	.532	.936
E100	5.08	18.1	351	242	136	98	55	45	32	28	18	15	10	8	8	6	3	100	170	220	.289	.864	1.52
E118	5.38	29.6	598	370	232	161	90	80	56	52	33	30	18	16	14	12	5	150	270	360	.470	1.41	2.48
E125	6.42	34.4	637	390	248	175	100	90	64	56	36	33	18	16	14	12	6	150	270	360	.547	1.64	2.88
E137	6.99	36.4	731	442	297	176	119	90	65	60	44	36	24	21	12	10	10	180	280	370	.579	1.73	3.05
E145	7.38	45.1	896	585	360	232	138	120	90	64	56	36	33	30	18	14	14	190	340	450	.717	2.15	3.77
E162	8.26	50.9	784	507	310	200	140	108	80	70	48	44	27	24	14	12	12	190	320	430	.809	2.42	4.26
E168	8.85	66.7	1460	944	564	370	240	189	144	126	95	64	60	39	33	30	18	270	470	620	1.06	3.18	5.58
E168A	9.35	73.1	1460	944	564	370	240	189	144	126	95	64	60	39	33	30	18	278	480	630	1.16	3.48	6.12
E187	9.50	67.4	952	585	396	232	161	120	90	80	56	48	33	30	18	14	14	210	370	500	1.07	3.21	5.64
E220	11.5	113	2024	1332	826	517	342	272	210	162	144	105	76	68	45	39	33	370	640	850	1.81	5.40	9.50
E225	11.4	97.6	1360	864	559	350	216	168	132	114	85	60	52	36	30	27	16	280	490	650	1.55	4.65	8.17
E305	15.5	208	3999	2600	1660	1072	689	564	420	342	272	210	162	144	105	78	68	610	1060	1400	3.30	9.88	17.4
E305A	16.3	226	3999	2600	1660	1072	689	564	420	342	272	210	162	144	105	78	68	620	1071	1400	3.59	10.8	18.9
E450	22.8	384	6298	4104	2580	1725	1100	833	704	546	420	341	280	225	176	133	102	850	1480	1970	6.10	18.3	32.1
E450H	21.1	328	6298	4104	2580	1725	1100	833	704	546	420	341	280	225	176	133	102	820	1420	1890	5.21	15.8	27.4

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PACKAGE SIZE AND WEIGHTS

Due to the relatively low price and high density of iron powder cores, freight charges can be a significant part of the total cost. The following table is provided to assist in planning shipment sizes and estimating freight costs.

Micrometals standard box size is 6 x 9 x 12 inches. Standard pallets contain 48 boxes with dimensions 38 x 48 x 32 inches. Weights specified below include box and packaging materials for the -26 Material. Weights for other material will vary in accordance with the densities listed on page 1. Add approximately 50 pounds for each pallet for large volume shipments.

Part Prefix	Qty./Box (pieces)	Weight/Box lbs/kg
T14A	250,000	41/19
T16	200,000	51/23
T20	100,000	45/20
T22	40,000	43/20
T25	40,000	39/18
T26	20,000	45/21
T27	30,000	41/19
T30	25,000	42/19
T37	20,000	44/20
T38	10,000	43/19
T40	10,000	37/17
T44	10,000	46/21
T44C	5,000	42/19
T44D	4,000	35/16
T50	6,000	37/17
T50B	5,000	41/19
T50C	3,000	34/15
T50D	3,000	37/17
T51C	4,000	43/19
T57	4,000	42/19
T57A	3,000	42/19
T60	3,000	36/16
T60D	1,600	39/18
T68	3,000	39/18
T68A	3,000	53/24
T68D	1,600	40/18
T69	1,600	43/19
T72	2,000	48/22
T80	2,000	40/18
T80B	1,250	39/18
T80D	1,000	42/19
T90	1,000	39/18
T94	1,250	46/21
T106	700	52/24
T106A	1,000	50/23
T106B	560	54/25
T124	600	37/17
T130	500	50/23
T130A	600	31/14
T131	500	59/27
T132	500	56/25
T141	400	42/19

Part Prefix	Qty./Box (pieces)	Weight/Box lbs/kg
T150	350	51/23
T150A	420	44/20
T157	240	45/20
T175	140	36/16
T184	140	51/23
T200	120	33/15
T200B	75	36/16
T201	90	52/24
T224C	90	50/23
T225	120	42/19
T225B	60	39/18
T249	45	40/18
T250	45	44/20
T300	54	31/14
T300D	30	35/16
T400	21	31/14
T400B	15	34/15
T400D	12	35/16
T520	12	34/15
T520D	6	33/15
T650	2	25/11
E49	10,000	24/17
E50	10,000	34/15
E65	4,000	27/12
E75	4,000	31/14
E80	3,000	38/17
E99	1,500	40/18
E100	2,000	34/15
E101	1,000	41/19
E118	1,225	44/20
E125	504	29/13
E137	800	39/18
E145	360	29/13
E162	300	34/15
E168	200	30/14
E168A	150	30/14
E187	240	48/22
E220	80	31/14
E225	110	38/17
E305	48	36/16
E305A	36	37/17
E450	18	37/17
E450H	36	40/18

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AL Value (nH/N^2): The inductance rating of a core in nanohenries (10^{-9} henries) per turn squared based on a peak AC flux density of 10 gauss (1 millitesla) at a frequency of 10 kHz. Note: 35.0 nH/N^2 = 350 µH for 100 turns = 35.0 mH for 1000 turns.

Butt-Gap: The gapping of E Cores by equally spacing all three legs of the cores rather than introducing a gap in the center-leg only. Twice as much center-leg gap is required to electrically duplicate a given butt-gap.

Choke: Another term for an inductor which is intended to filter or choke out signals.

Common-Mode Noise: Electrical interference that is common to both lines in relation to earth ground. Copper Loss (watts): The power loss (I^2R) or heat generated by current (I) flowing in a winding with resistance (R).

Core Loss (watts): The power loss or heat generated by a magnetic material subjected to an alternating magnetic field.

Cross-Sectional Area (A): The effective cross-sectional area (cm^2) of a core available for magnetic flux. The crosssectional area listed for toroidal cores is based on bare core dimensions with a 5% radius correction.

Differential-Mode Noise: Electrical interference that is not common to both lines but is present between both lines. This is also known as normal-mode noise.

Energy Storage ($^1/_2LI^2$): The amount of energy stored in microjoules (10^{-6} joules) is the product of one-half the inductance (L) in microhenries (10^{-6} henries) times the current (I) squared in amperes.

Full Winding: A winding for toroidal cores which will result in 45% of the core's inside diameter remaining. A winding for E Cores which will result in a full bobbin. The type of insulation, tightness of winding, and coil winding equipment limitations will all introduce variations.

Initial Permeability (μ_o): That value of permeability at a peak AC flux density of 10 gauss (1 millitesla). µ=B/H. The permeability listed for each material is for reference only. The cores are manufactured to the listed A_L values.

Magnetizing Force (H): The magnetic field strength which produces magnetic flux. 1 oersted = 79.58 A/m = .7958 A/cm

In cgs units:

$$H = \frac{.4\pi N I}{\ell}$$

Where: H = oersteds (Oe)
N = Number of turns
I = Current (amperes)
ℓ = Mean Magnetic Path (cm)

In SI units:

$$H = \frac{N I}{\ell}$$

Where: H = amperes per meter
N = Number of turns
I = Current (amperes)
ℓ = Mean Magnetic Path (cm)

Mean Magnetic Path Length (ℓ): The effective magnetic length of a core structure (cm).

MLT (cm): The mean length per turn of wire for a core. See figures on pages 64 and 65.

Peak AC Flux Density (Bpk): The number of lines of flux per unit of cross-sectional area generated by an alternating magnetic field (from zero or a net DC). In general: (1 gauss = 10^{-4} tesla)

In cgs units:

$$B_{pk} = \frac{E_{avg}\,10^8}{4\,A\,N\,f}$$

Where:
B_{pk} = Gauss (G)
E_{avg} = Average voltage per half cycle (volts)
A = Cross-sectional area (cm^2)
N = Number of turns
F = Frequency (hertz)

Peak to Peak Flux Density (ΔB): In an alternating magnetic field, it is assumed that the peak to peak flux density is twice the value of peak AC flux density. $\Delta B = 2\,B_{pk}$.

Percent Initial Permeability (%μ_o): Represents the percent change in permeability from the initial value. Since the cores are manufactured to the A_L value rather than to the listed reference permeability, this can also be considered Percent A_L Value.

Percent Ripple: The percentage of ripple or AC flux to total flux; or in an inductor, the percentage of alternating current to average current.

Percent Saturation: This is equal to 100% – Percent Initial Permeability. ie: 20% saturation = 80% of initial permeability.

Simple Winding: A winding for toroidal cores which will result in 78% of the core's inside diameter remaining. Often times this will produce a single-layer winding.

Single-Layer Winding: A winding for a toroidal core which will result in the full utilization of the inside circumference of the core without the overlapping of turns. The thickness of insulation and tightness of winding will affect results.

Swing: A term used to describe how inductance responds to changes in current. Example: A 2:1 swing corresponds to an inductor which exhibits 2 times more inductance at very low current than it does at its maximum rated current. This would also correspond to the core operating at 50% of initial permeability (also 50% saturation) at maximum current.

Surface Area (cm^2): The effective surface area of a typical wound core available to dissipate heat. See figures on pages 64 and 65.

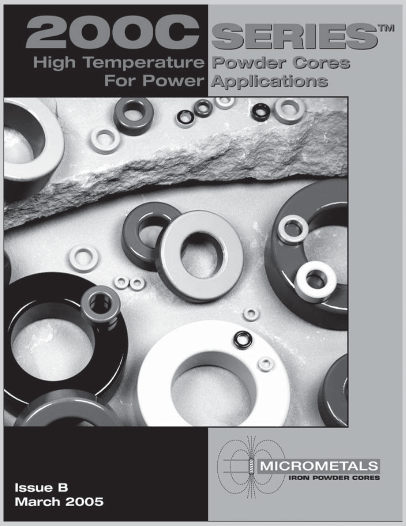
Temperature Rise (ΔT): The increase in surface temperature of a component in free-standing air due to the total power dissipation (both copper and core loss). See pages 64 and 65.

The following formula has been used to approximate temperature rise:

$$\Delta T\,(C^\circ) = \left[\frac{\text{Total Power Dissipation (milliwatts)}}{\text{Surface Area (cm}^2\text{)}}\right]^{.833}$$

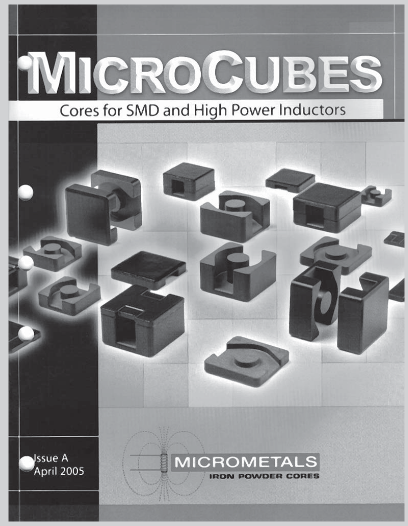
ADDITIONAL LITERATURE

200C Series™
High Temperature Powder Cores



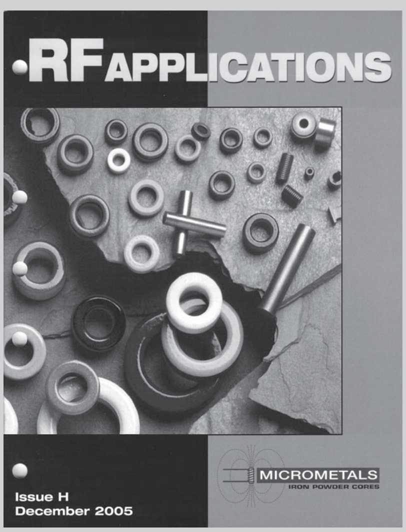
Micrometals 200C Series™ of magnetic alloy materials are specifically designed for severe environment applications where cores are exposed to or generate elevated temperatures. These cost competitive core materials are not subject to thermal aging for operating temperatures up to +200°C. Materials permeabilities range from 35 to 125 with toroid geometries up to 4.0 inches and E-cores up to 4.5 inches.

Microcubes
Low Profile Linear Wound HC/IC Cores

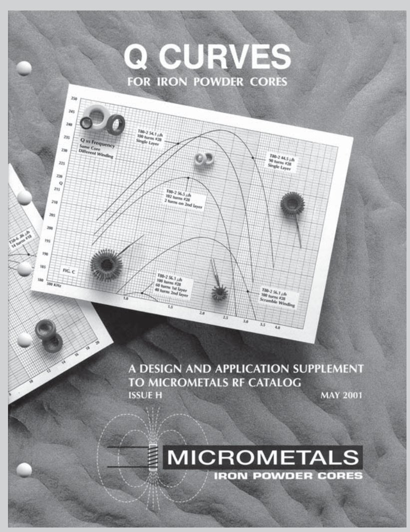


Micrometals series of cores for high density inductors are well-suited for either through-hole or surface mount applications. Microcubes are ideal for low inductance, high current applications such as voltage regulated modules (VRM's), point of load power supplies and other DC/DC applications. The geometries shown in this catalog are offered in traditional iron powder material and magnetic alloy powder.

Radio Frequency Applications



Q Curves
Supplement to RF Catalog



Micrometals RF catalog contains iron powder toroids, balun core, plain cores, hollow cores, sleeves, threaded cores, cups, disks, bobbins, bobbin sleeves and squared bobbins in the following materials: -1, -2, -3, -4, -6, -7, -10, -12, -17, -42 and -0. Permeabilities range from 1 to 35 for applications from 10 khz to 500 MHz.

The Q Curve catalog is a design and application supplement containing over 30 pages of Q versus Frequency curves and other useful information.

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TEL. (714) 970-9400
FAX (714) 970-0400

5615 E. LA PALMA AVE. ANAHEIM, CA 92807 USA

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IRON POWDER CORES