IRON POWDER TOROIDAL CORES

FOR
DC CHOKES and AC LINE FILTERS

For many years Iron Powder has been used as the core material for RF inductors and transformers when stability and high 'Q' are of primary concern. Because of the growing need for energy storage inductors for noise filtering, new materials have been developed for these applications

High 'Q' inductors are no longer required, in fact low 'Q' actually helps in damping high frequency oscillations. The #26 Iron Powder material is ideally suited for these applications since it combines low 'Q', good frequency response, and high energy capabilities.

Energy storage , expressed in microjoules, is calculated by multiplying one-half the inductance in µh times the current in amperes squared. The amount of energy that can be stored in a given inductor is limited either by saturation of the core material or temperature rise of the wound unit, resulting in copper loss and/or core loss.

In typical DC chokes, the AC ripple flux is normally small in comparison to the DC component. Since the DC flux does not generate core loss, our primary concern becomes saturation and copper loss. The DC saturation characteristics of the #26 material are shown in Fig. A on the following page.

Using this information, DC energy storage curves have been developed and presented in the chart on the 2nd following page. A table of energy storage limits vs. temperature rise is included in the chart. The table at the bottom of the page is for single layer winding.

In 60 Hz. line filter applications, the high frequency to be filtered falls into two categories: (1) Common-mode noise and (2) Differential-mode noise. The common-mode noise is in relation to earth ground and is common to both lines. Differential mode noise is the noise between the two lines.

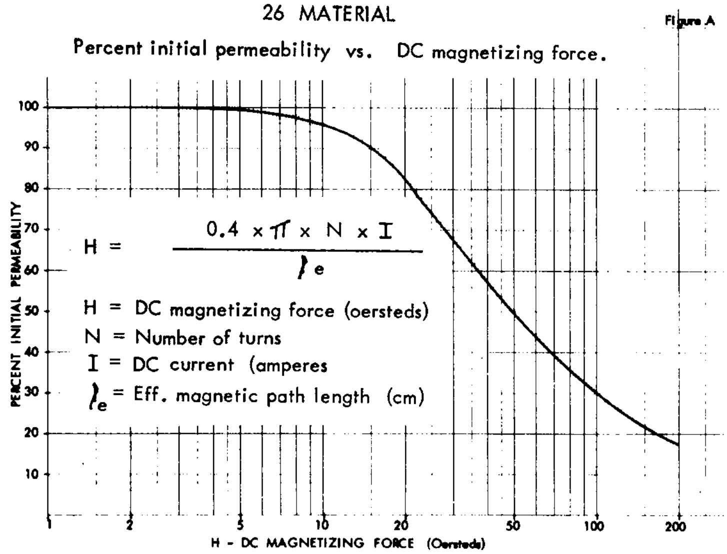
The Common-mode noise filter is usually constructed on a high permeability ferrite type core with a bifilar type winding. This type of winding allows the 60 Hz. flux generated by each line to cancel within the core, thus avoiding saturation. If the #26 Iron Powder material were to be used, the large core size necessary to accommodate the required number of wire turns for the required inductance makes this option unattractive.

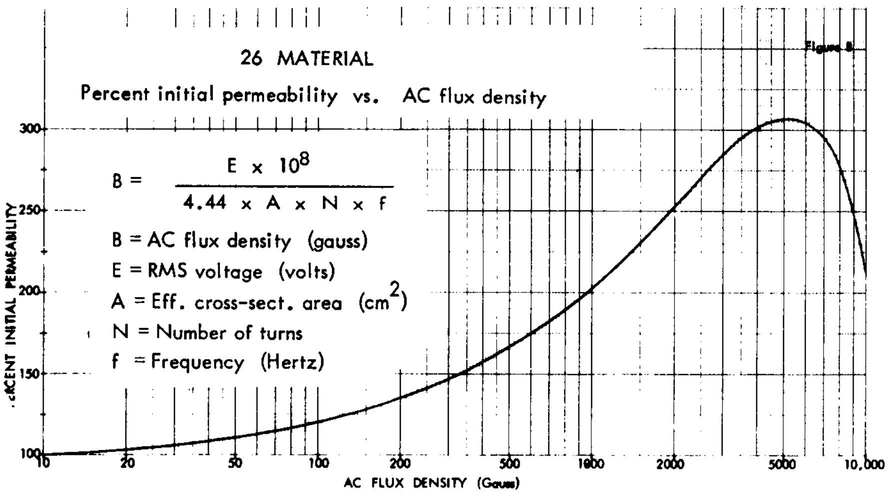
The Differential-mode filters must be able to support a significant amount of 60 Hz. flux without saturating. The AC saturation characteristics of the #26 material (Fig. B) and core loss information (Fig. C) can be seen on the following page. Notice how the permeability initially increases with AC excitation. This effect allows greater energy storage in 60 Hz. applications.

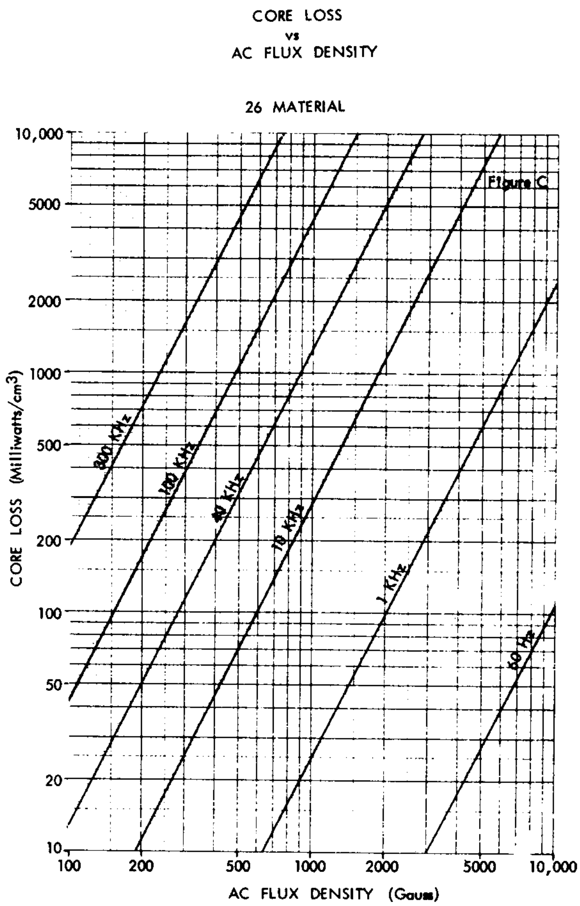
Energy storage curves have been developed for line filter applications as shown on the 3rd following page. The energy storage limit table is now taking into account both the core and the copper loss. In order to guarantee a minimum inductance over a wide current range, the design engineer may wish to calculate the required turns based on the listed A_L value of the core.

CORES FOR DC CHOKES AND AC LINE FILTERS

MATERIAL 26		Permeabilty 75		DC to 1 MHz (Low 'Q')		Color - Yellow & White	
Core number	O.D. (inches)	I.D. (inches)	Hgt. (inches)	ℓ_e (cm)	A_e $(cm)^2$	V_e $(cm)^3$	A_L Value μh/100 turns
T-30-26	.307	.151	.128	1.83	.065	.119	325
T-37-26	.375	.205	.128	2.32	.070	.162	275
T-44-26	.440	.229	.159	2.67	.107	.286	360
T-50-26	.500	.303	.190	3.03	.121	.367	320
T-68-26	.690	.370	.190	4.24	.196	.831	420
T-80-26	.795	.495	.250	5.15	.242	1.246	450
T-94-26	.942	.560	.312	6.00	.385	2.310	590
T-106-26	1.060	.570	.437	6.50	.690	4.485	900
T-130-26	1.300	.780	.437	8.29	.730	6.052	785
T-157-26	1.570	.950	.570	10.05	1.140	11.457	970
T-184-26	1.840	.950	.710	11.12	2.040	22.685	1640
T-200-26	2.000	1.250	.550	12.97	1.330	17.250	895
T-200A-26	2.000	1.250	1.000	12.97	2.240	29.050	1525
T-225-26	2.250	1.405	.550	14.56	1.508	21.956	950
T-225A-26	2.250	1.485	1.000	14.56	2.730	39.749	1600
T-300-26	3.058	1.925	.500	19.83	1.810	35.892	800
T-300A-26	3.048	1.925	1.000	19.83	3.580	70.991	1600
T-400-26	4.000	2.250	.650	24.93	3.660	91.244	1300
T-400A-26	4.000	2.250	1.300	24.93	7.432	185.280	2600
T-520-26	5.200	3.080	.800	33.16	5.460	181.000	1460

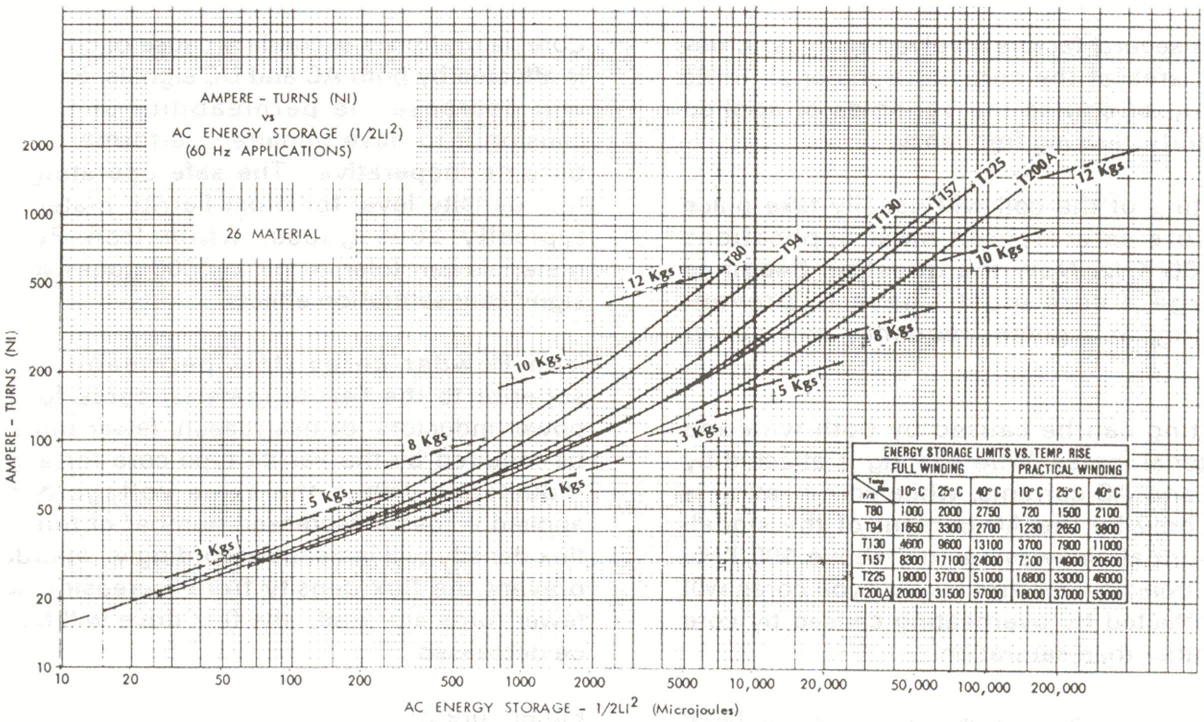






IRON POWDER TOROIDAL CORES

AC Line Filters



60 HZ. AC LINE FILTER APPLICATIONS (single layer winding)

DC Amps Wire size	1 Amp 28 AWG	2 Amps 24 AWG	4 Amps 21 AWG	6 Amps 19 AWG	10 Amps 15 AWG	15 Amps 13 AWG	20 Amps 11 AWG	30 Amps 9 AWG
Part No. T-37 -26*	130 μh 41 turns	50.0 μh 27 turns	15 μh 15 turns	6.7 μh 10 turns	2.4 μh 6 turns	1.1 μh 4 turns	.60 μh 3 turns	.07 μh 1 turn
T-50 -26*	460 μh 63 turns	150 μh 37 turns	58.8 μh 25 turns	26.1 μh 17 turns	9.4 μh 10 turns	4.2 μh 7 turns	2.4 μh 5 turns	1.0 μh 3 turns
T-80 -26	1600 μh 108 turns	550 μh 66 turns	213 μh 45 turns	94.4 μh 30 turns	34.0 μh 18 turns	15.1 μh 12 turns	8.5 μh 9 turns	3.8 μh 6 turns
T-94 -26	2899 μh 123 turns	950 μh 75 turns	375 μh 52 turns	156 μh 33 turns	56.0 μh 20 turns	24.9 μh 13 turns	14 μh 10 turns	6.2 μh 7 turns
T-130 -26	7200 μh 173 turns	2500 μh 107 turns	1000 μh 75 turns	444 μh 50 turns	160 μh 30 turns	71.1 μh 20 turns	40 μh 15 turns	17.8 μh 10 turns
T-157 -26	13.6 mh 213 turns	4650 μh 139 turns	1810 μh 93 turns	806 μh 62 turns	290 μh 37 turns	129 μh 25 turns	72.5 μh 18 turns	32.2 μh 12 turns
T-184 -26*	22 mh 213 turns	7750 μh 132 turns	3130 μh 93 turns	1390 μh 62 turns	500 μh 37 turns	222 μh 25 turns	125 μh 18 turns	56.6 μh 12 turns
T-225 -26	26 mh 317 turns	9000 μh 198 turns	3500 μh 139 turns	1940 μh 110 turns	700 μh 66 turns	311 μh 44 turns	175 μh 33 turns	77.8 μh 22 turns
T-300A -26*	84 mh 435 turns	29 mh 272 turns	11.2 mh 190 turns	6390 μh 151 turns	2360 μh 93 turns	1240 μh 72 turns	750 μh 56 turns	356 μh 40 turns
T-400A -26*	180 mh 507 turns	61 mh 317 turns	25.6 mh 223 turns	14.2 mh 176 turns	5300 μh 108 turns	2800 μh 83 turns	1650 μh 65 turns	800 μh 46 turns

Note: * Size not shown on above curve chart. ** Wire size based on Max. Temp. rise 40° C.

POWER CONSIDERATIONS (Iron Powder and Ferrite)

How large a core is needed to handle a certain amount of power? This is a question often asked. Unfortunately, there is no simple answer.

There are several factors involved such as: cross sectional area of the core, core material, turns count, and of course the variables of applied voltage and operating frequency.

Overheating of the coil will usually take place long before saturation in most applications above 100 KHz. Now the question becomes 'How large a core must I have to prevent overheating at a given frequency and power level'?

Overheating can be caused by both wire and core material losses. Wire heating is affected by both DC and AC currents, while core heating is affected only by the AC content of the signal. With a normal sinewave signal above 100 KHz, both the Iron Powder and Ferrite type cores will first be affected by overheating caused by core losses, rather than saturation.

The extrapolated AC flux density limits (see table below) can be used for BOTH Iron Powder and Ferrite type cores as a guideline to avoid excessive heating. These figures may vary slightly according to the type of the material being used.

Operating frequency is one of the most important factors concerning power capability above 100 KHz. A core that works well at 2 MHz. may very well burn up at 30 MHz. with the same amount of drive.

Core saturation, a secondary cause of coil failure, is affected by both AC and DC signals. Saturation will decrease the permeability of the core causing it to have impaired performance or to become inoperative. The safe operating total flux density level for most Ferrite materials is typically 2000 gauss, while Iron Powder materials can tolerate up to 5000 gauss without significant saturation effects.

Iron Powder cores (low permeability) are superior to the Ferrite material cores for high power inductors for this reason: fewer turns will be required by the Ferrite type core for a given inductance. When the same voltage drop is applied across a decreased number of turns, the flux density will increase accordingly. In order to prevent the flux density from increasing when fewer turns are used, the flux drive will have to be decreased.

Either core material can be used for transformer applications but both will have 'trade-offs'. Ferrite type cores will require fewer turns, will give more impedance per turn and will couple better, whereas the Iron Powder cores will require more turns, will give less impedance per turn, will not couple as well but will tolerate more power and are more stable.

Frequency:	100 KHz	1 MHz	7 MHz	14 MHz	21 MHz	28 MHz
AC Flux Den.	500 gauss	150 gauss	57 gauss	42 gauss	36 gauss	30 gauss

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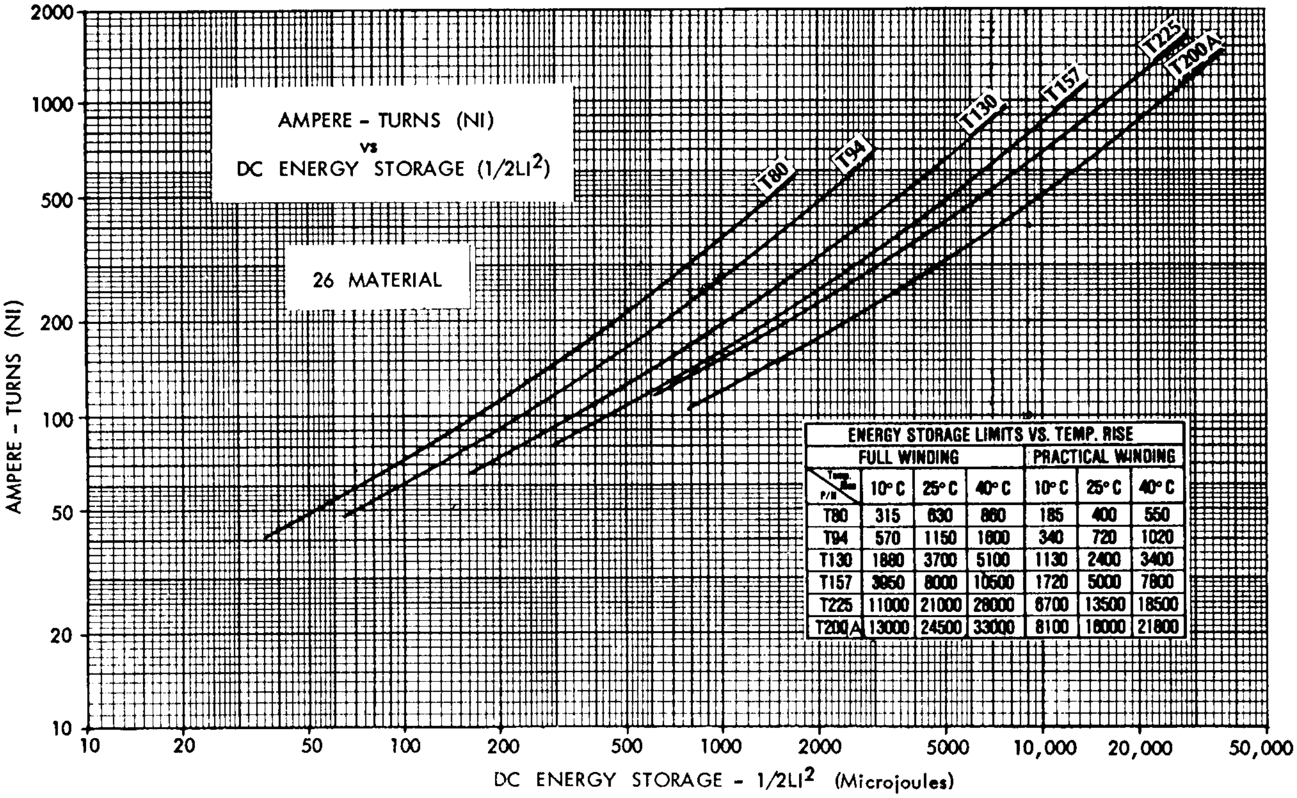
DC Chokes



ENERGY STORAGE LIMITS VS. TEMP. RISE						
	FULL WINDING			PRACTICAL WINDING		
Temp. Rise / P/N	10° C	25° C	40° C	10° C	25° C	40° C
T80	315	630	860	185	400	550
T94	570	1150	1600	340	720	1020
T130	1880	3700	5100	1130	2400	3400
T157	3950	8000	10500	1720	5000	7800
T225	11000	21000	28000	6700	13500	18500
T200A	13000	24500	33000	8100	16000	21800

DC CHOKES APPLICATIONS (single layer winding)

DC Amps Wire size	1 Amp 28 AWG	2 Amps 24 AWG	4 Amps 21 AWG	6 Amps 19 AWG	10 Amps 16 AWG	15 Amps 14 AWG	20 Amps 12 AWG	30 Amps 10 AWG
Part No. T-37-26*	35 μh 41 turns	13.5 μh 27 turns	4.0 μh 15 turns	1.8 μh 10 turns	.8 μh 7 turns	.38 μh 5 turns	.16 μh 3 turns	.012 μh 1 turn
T-50-26*	92 μh 63 turns	29.0 μh 37 turns	11.3 μh 25 turns	5.5 μh 18 turns	2.1 μh 11 turns	1.1 μh 8 turns	.59 μh 6 turns	.36 μh 5 turns
T-80-26	380 μh 108 turns	130 μh 66 turns	51.3 μh 45 turns	27.8 μh 35 turns	11.2 μh 23 turns	5.7 μh 17 turns	3 μh 12 turns	1.3 μh 8 turns
T-94-26	650 μh 123 turn	220 μh 75 turns	87.5 μh 52 turns	47.2 μh 40 turns	20.0 μh 27 turns	10.2 μh 20 turns	5.3 μh 14 turns	2.6 μh 10 turns
T-130-26	1660 μh 173 turns	575 μh 107 turns	231 μh 75 turns	27 μh 58 turns	55.0 μh 40 turns	28.0 μh 30 turns	16.5 μh 23 turns	10.4 μh 17 turns
T-157-26	3200 μh 213 turns	1100 μh 122 turns	438 μh 93 turns	244 μh 73 turns	106 μh 50 turns	55.6 μh 38 turns	32 μh 29 turns	16.4 μh 22 turns
T-184-26*	5600 μh 213 turns	1950 μh 122 turns	788 μh 93 turns	439 μh 73 turns	190 μh 50 turns	99.6 μh 38 turns	57.5 μh 29 turns	29.3 μh 22 turns
T-225-26	8600 μh 317 turns	2300 μh 198 turns	938 μh 139 turns	528 μh 110 turns	230 μh 77 turns	127 μh 60 turns	72.5 μh 46 turns	40 μh 36 turns
T-300A-26*	22.4 mh 435 turns	7850 μh 272 turns	3120 μh 190 turns	1750 μh 151 turns	760 μh 105 turns	418 μh 82 turns	250 μh 63 turns	129 μh 44 turns
T-400A-26*	51.0 mh 507 turns	17.5 mh 317 turns	7120 μh 223 turns	4000 μh 176 turns	1760 μh 122 turns	951 μh 95 turns	550 μh 73 turns	293 μh 57 turns

Note: * Size not shown on above curve chart. ** Wire size based on Max. Temp. rise 40° C.