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Four kicker injection into the booster

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Collider Accelerator Department

Brookhaven National Laboratory

U.S. Department of Energy

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DISCLAIMER

FOUR KICKER INJECTION INTO THE BOOSTER

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Injection into a long straight section avoids the special modification of a dipole magnet to accommodate the passage of the injection beam. All injection options are being studied and the kicker design described herein is intended to facilitate this study. Three designs are reviewed corresponding to three possible straight section lengths. Figure 1 shows the basic concept. The incoming beam must miss an edge of the last quadrupole magnet which is 33 cm. out from center line at the straight section end. A septum magnet is required to bend this incoming beam and inject it into the second of the four kickers as shown. To accommodate this septum the first kicker magnet must be a "C" type magnet as shown in figure 2. If it were an "H" type magnet its backleg would physically interfere with the septum magnet.

Since the design of the booster is still being studied with the lattice and straight section lengths subject to change, three designs are presented. The most compact design is planned to go into a straight section length of only 370 cm. The other two designs are planned to 430 and 500 cm. respectively. Table I lists the parameters of all three designs. The 370 cm. design is very compact and a magnetic field of 2845 gauss is required which is very high for a ferrite magnet. Therefore, I believe that this design is not practical, although it could be built, if there was no alternate. I believe the other two designs are practical although the 430 cm design may become crowded when foil holding mechanisms are included. For reference I have included a specification sheet for ferrite material 3C8 which I believe to be typical for ferrite materials that could be used in the construction for these magnets.

Two powering pulse forms have been suggested to power these kicker magnets. The first is a 500 microsecond long rectangular pulse with a 25 microsecond rising and falling edges. The second proposal is to use the back side of a cluster of half sine waves to create a falling contoured wave form which allows the injected beam to paint the available phase space uniformly. I have designed both types of pulsing systems. In both cases the magnets are connected in series and powered from a common source.

The rectangular pulse is generated from a pulse forming network controlled by a SCR switch. The electrical parameters of the system are listed in Table IIA. The pulse voltage varies from 5.9 to 7.75 KV with a generator characteristic impedance of about 0.5 ohms. This network can be located outside the shielding and connected with a parallel plate transmission line having the same characteristic impedance.

Table IIB shows the electrical parameters of the principle half sine wave generator of the cluster. The number and magnitude of the other generators in the set are smaller and can be adjusted to fit the desired injection contour.

TABLE I Kicker Parameters				
Straight Section Length	cm	378	430	500
Kick Amplitude	cm	7.6	7.6	7.6
Kicker Length, Physical	cm	67.5	77.5	82.5
Kicker Length, Effective	cm	74.1	84.1	89.1
Kick Angle	degrees	5.60	4.46	4.24
End Space	cm	30	30	45
Drift Space	cm	10	20	20
Center Space	cm	20	20	40
Magnetic Field	gauss	2845	2000	1790
Aperture Width	cm	23	23	23
Aperture Height	cm	6.6	6.6	6.6

TABLE IIA

Kicker Electrical Parameters

Rectangular Pulse

Straight Section Length	cm	370	430	500
Kicker Inductance	μh	3.25	3.68	3.90
Series Inductance	μh	13	14.7	15.6
I Max	KA	14.9	10.5	9.4
Pulse Length	μ sec	500	500	500
Rise Time	μ sec	25	25	25
Pulse E (series connected)	KV	7.75	6.17	5.87
Storage Network, Z_0	Ohms	0.52	0.59	0.62
L Per Section, 20 Sections	μh	6.5	7.4	7.8
C Per Section, 20 Sections	μf	24	21	20
C Total, 20 Sections	μf	480	420	400

TABLE IIB Kicker Electrical Parameters Falling Half Sine Ware				
Straight Section Length	cm	370	430	500
Kicker Inductance, Series	μh	13	14.7	15.6
Current at 1st Injection	KA	14.9	10.5	9.4
Crest Current	KA	21.1	14.8	13.3
Energy Storage C	μf	700	620	585
Storage Voltage	Volts	1450	1100	1000
Half Period	μ sec	300	300	300

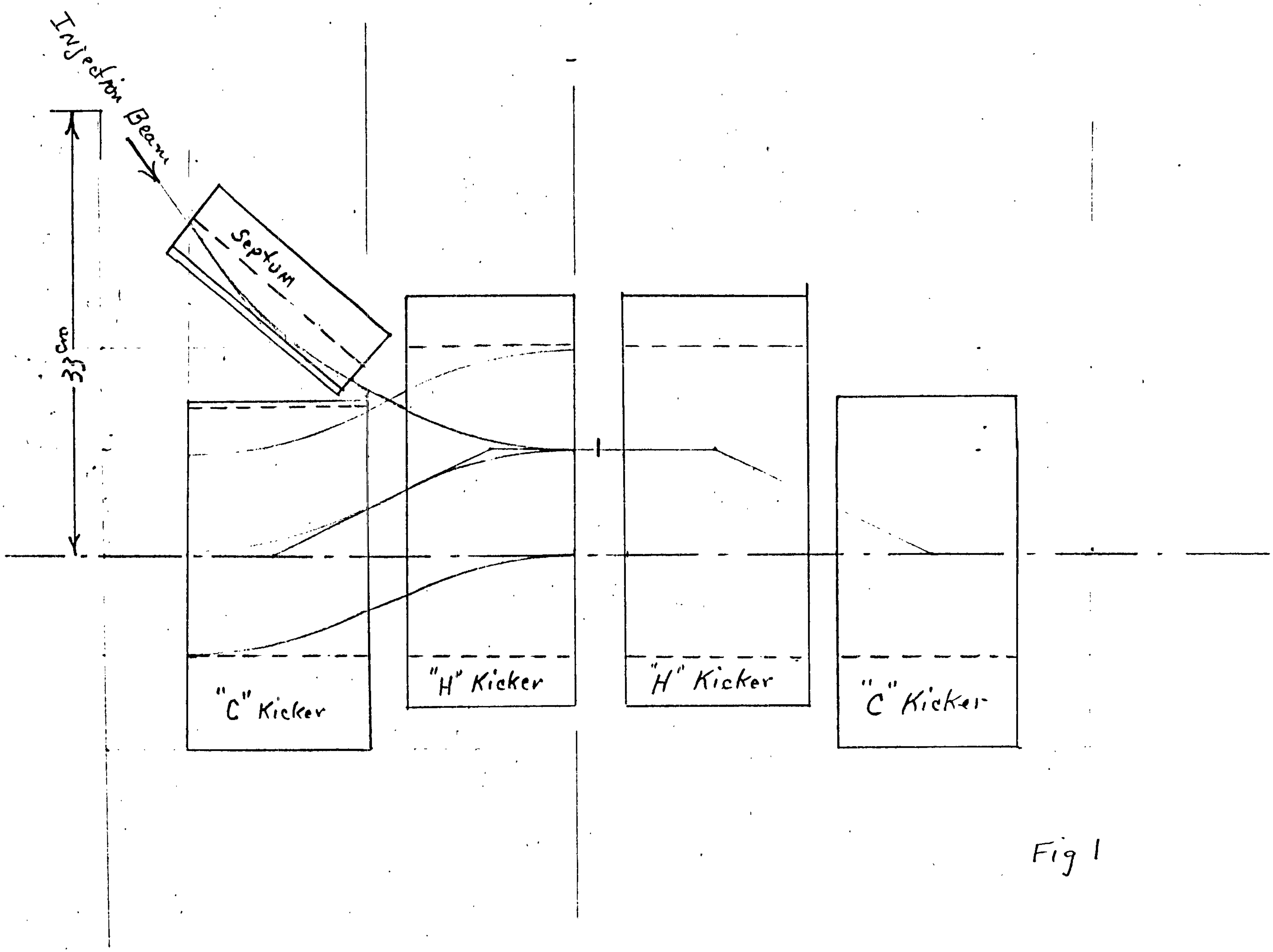

Injection Beam
Septum
33 cm
"C" Kicker
"H" Kicker
"H" Kicker
"C" Kicker

Fig 1

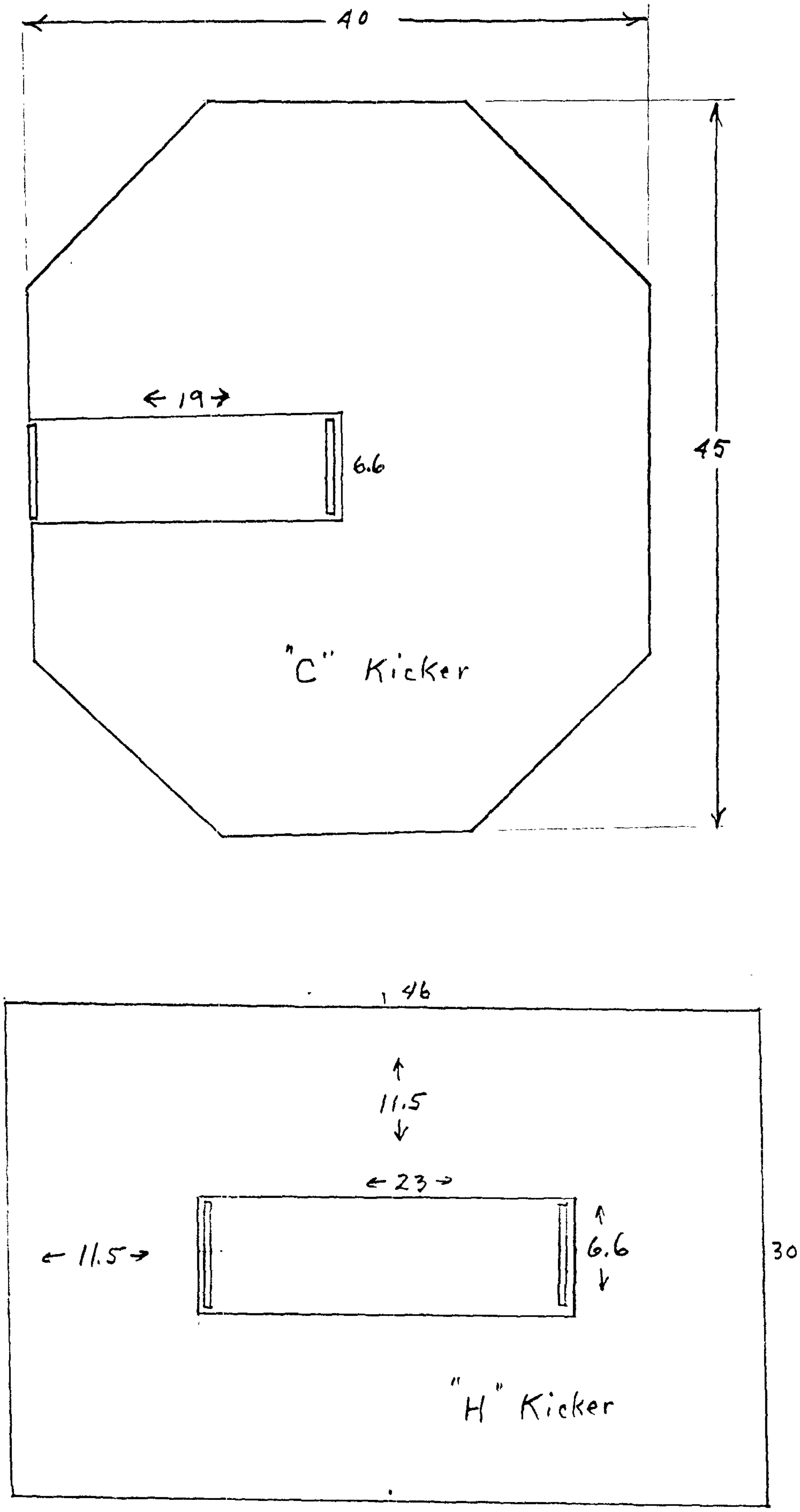


Fig 2

Scale - 100cm = 1"

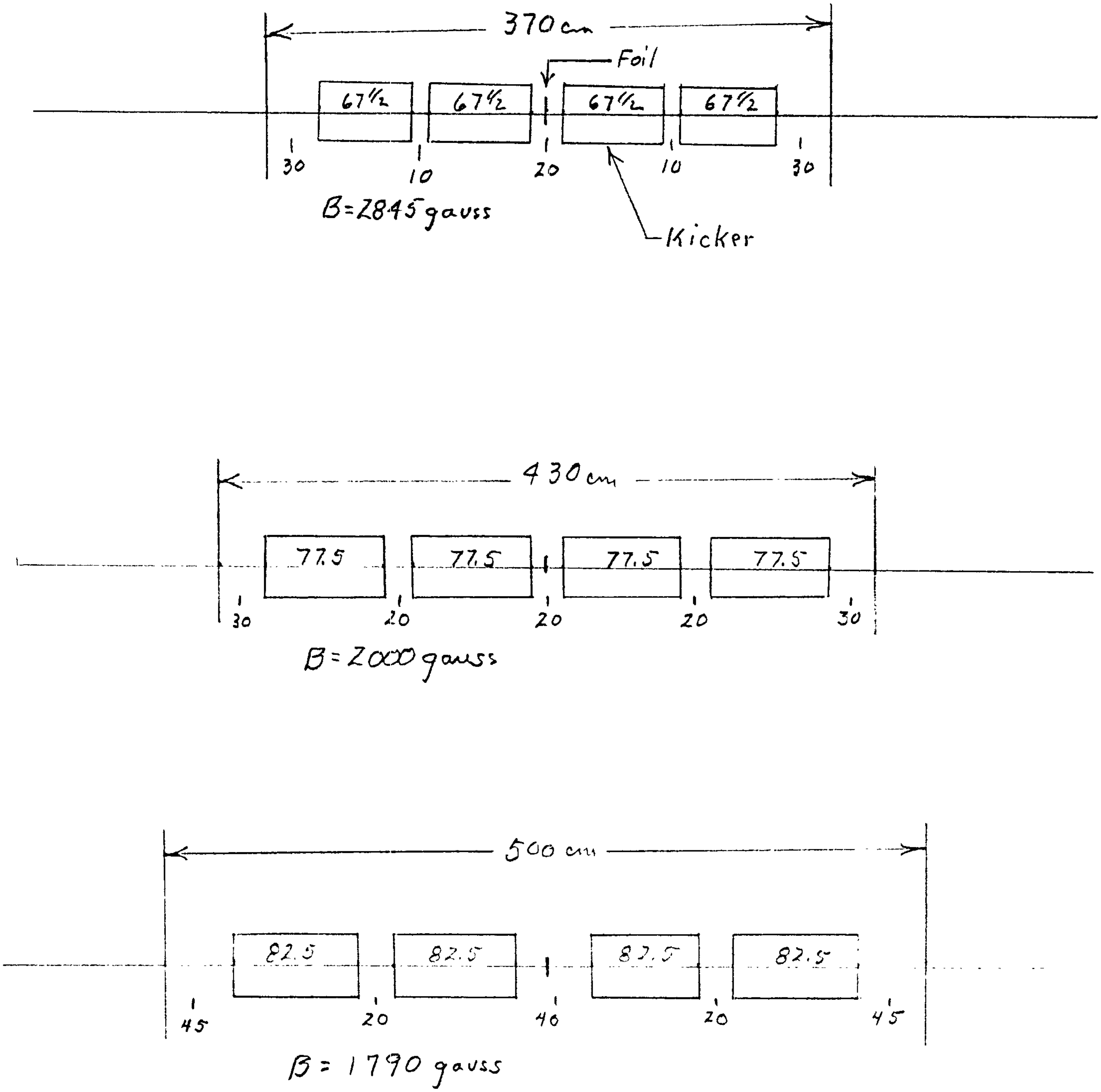


Fig 3

3C8 FERRITE

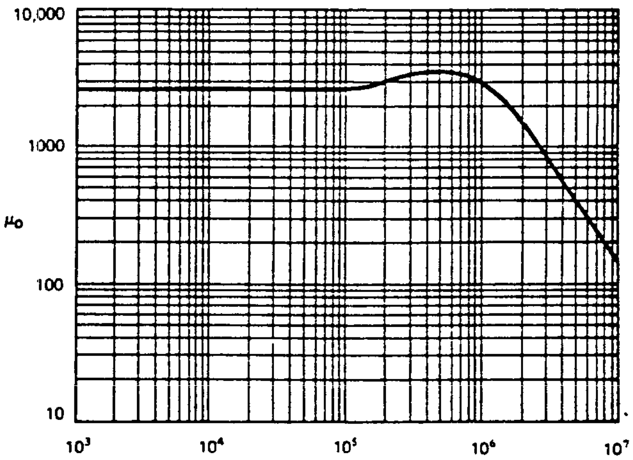
3C8 MATERIAL

A Manganese-Zinc ferrite designed for high-flux-density applications. It offers medium permeability, low losses under high flux levels, high B saturation, and a high Curie temperature.

Available in:

- POT CORES
- E, U, & I CORES
- TOROIDS

INITIAL PERMEABILITY (μ_o) vs. FREQUENCY



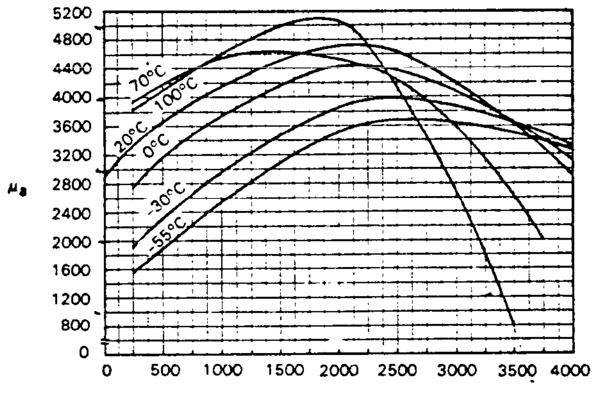
3C8 CHARACTERISTICS

Parameters shown are typical values, based upon measurements of a 1" toroid.

Initial Permeability at 25°C, 100KHz ≤ 1 gauss	μ_o	2700 (±20%)
Saturation Flux Density (H = 3 oersteds)		
at 25°C	B_s	≥ 4400 gauss
at 100°C	B_s	≥ 3300 gauss
Coercive Force	H_c	.20 oersteds*
Residual Flux Density	B_r	1000 gauss*
Loss Factor at 100KHz ≤ 1 gauss	$\frac{\tan\delta}{\mu_o}$	$\leq 10 \times 10^{-6}$
Losses 25KHz, 100°C, 1600 gauss		≤ 115 mW/cm³
Curie Temperature	T_c	≥ 210°C

*Typical Values

PERMEABILITY (μ_a) vs. FLUX DENSITY ($\hat{B}$)



INITIAL PERMEABILITY (μ_o) vs TEMPERATURE