Introduction

History

The history of magnetism began with the discovery of the properties of a mineral called magnetite (Fe_3O_4). The most plentiful deposits were found in the district of Magnesia in Asia Minor (hence the mineral's name) where it was observed, centuries before the birth of Christ, that these naturally occurring stones would attract iron. Later on it found application in the lodestone of early navigators. In 1600 William Gilbert published *De Magnete*, the first scientific study on magnetism. In 1819 Hans Christian Oersted observed that an electric current in a wire affected a magnetic compass needle, thus with later contributions by Faraday, Maxwell, Hertz and others, the new science of electromagnetism came into being.

Even though the existence of naturally occurring magnetite, a weak type of hard ferrite, had been known since antiquity, producing an analogous soft magnetic material in the laboratory proved elusive. Research on magnetic oxides was going on concurrently during the 1930's, primarily in Japan and the Netherlands. However, it was not until 1945 that J. L. Snoek of the Philips' Research Laboratories in the Netherlands succeeded in producing a soft ferrite* material for commercial applications.

Fair-Rite Products Corp. was not far behind in the manufacture and sale of soft ferrites for use in the electronics industry. It was formed in 1952 and officially started operations in 1953. The ensuing years have seen a rather crude product, which was available in only a few shapes and materials, develop into a major line of ferrite components for inductive devices, produced in many core configurations with a wide selection of materials. The application of ferrites in EMI suppression as shield beads and broadband chokes, where an effective resistive impedance is produced at high frequencies, has grown so fast in the last decade, that their use as EMI suppressors is limited only by the imagination of the end user.

Soft Ferrites

The single most important characteristic of soft ferrites, as compared to other magnetic materials, is the high volume resistivity exhibited in the monolithic form. Since eddy current losses are inversely proportional to resistivity and these losses increase with the square of the frequency, high resistivity becomes an essential factor in magnetic materials intended for high frequency operation. The magnetic properties of ferrite components are isotropic, and by employing various pressing, injection molding, and/or grinding techniques, a wide range of complex shapes can be formed. There is no other class of magnetic material that can match soft ferrites in performance, cost and volumetric efficiency, over the range from audio frequencies to above 500 MHz.

During the last 50 years the basic constituents of ferrites have changed little, but purity of raw materials and process control have improved dramatically. Ferrites are ceramic materials with the general chemical formula $MO.Fe_2O_3$, where MO is one or more divalent metal oxides blended with 48 to 60 mole percent of iron oxide. Fair-Rite manufactures three broad groups of soft ferrite materials:

Manganese zinc (Fair-Rite 31, 33, 73, 75, 76, 77 and 78 material)

Nickel zinc (Fair-Rite 42, 43, 44, 51, 61, 67 and 68 material)

Manganese (Fair-Rite 85 material)

Manganese zinc ferrites are completely vitrified and have very low porosity. They have the highest permeabilities and exhibit volume resistivities ranging from one hundred to several thousand ohm-centimeter. Manganese zinc ferrite components are used in tuned circuits and magnetic power designs from the low kilohertz range into the broadcast spectrum. These ferrites have a linear expansion coefficient of approximately 10 ppm/°C.

The nickel zinc ferrites vary in porosity, and frequently contain oxides of other metals, such as those of magnesium, manganese, copper or cobalt. Volume resistivities range from several kilohm-centimeter to tens of megohm-centimeter. In general, they are used at higher frequencies (above 1 MHz), and are suitable for low flux density applications. Nickel zinc ferrites have a linear expansion coefficient of approximately 8 ppm/°C.

The manganese ferrite is a dense, temperature stable material displaying a high degree of squareness in its hysteresis loop. This makes this material uniquely suited for such applications as multiple output control in switched-mode power supplies and high frequency magnetic amplifiers.

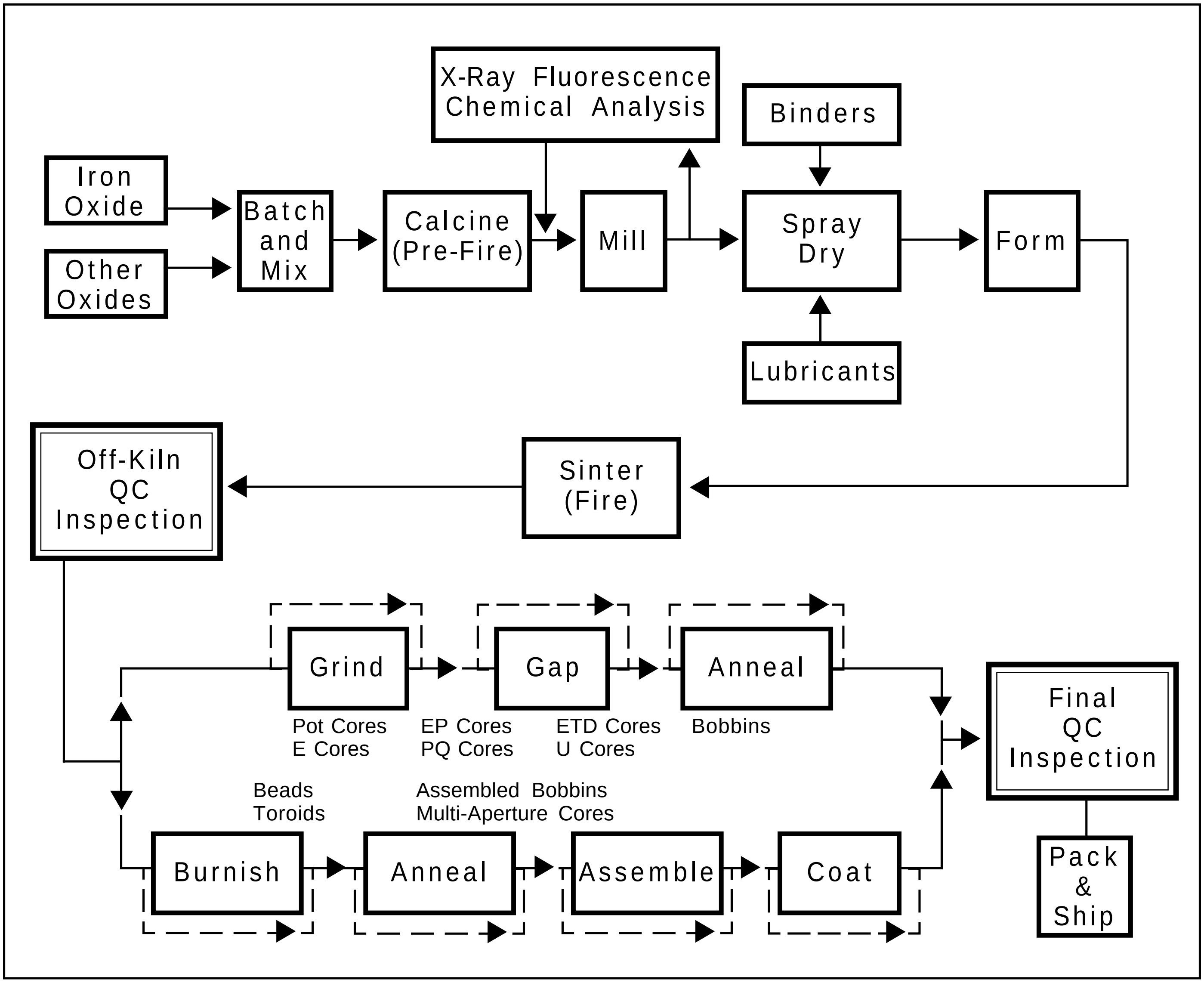
As is evident from the flow diagram on page 3, there is considerable processing involved, and the manufacturing cycle will take a minimum of two weeks. The parts listed in the catalog represent a broad cross section of the wide variety of cores produced by Fair-Rite Products. Large OEM quantitites are manufactured by Fair-Rite to order. Most of the more commonly used parts are stocked by our distributors, offering prompt deliveries. For a complete listing of our distributors visit our site on the Internet at www.fair-rite.com.

Many of the parts produced by Fair-Rite are made to customer specifications, and we welcome inquiries involving application-specific designs. We have the capability to design tooling rapidly, and have it fabricated either by our own tool shop or by outside vendors.

***Footnote:** *The difference between hard and soft ferrite is not tactile, but rather a magnetic characteristic. Soft ferrite does not retain significant magnetization, whereas hard ferrite magnetization is considered permanent.*

Introduction

Simplified Process Flow Diagram



Fair-Rite Products Corp.
CAGE # 34899
Federal ID# 141389596

Ferrite Cores
Standard Industrial Classification (SIC) 3264
North American Industry
Classification System (NAICS) 327113

Magnetic Properties of Ferrite Materials

Property	**Unit**	**Symbol**	**68**	**67**	**61**	**51***	**44**
Initial Permeability @ B <10 gauss		μ_i	20	40	125	350	500
Flux Density	gauss mT	B	2700 270	2300 230	2350 235	3200 320	3000 300
@ Field Strength	oersted A/m	H	40 3200	20 1600	15 1200	10 800	10 800
Residual Flux Density	gauss mT	B_r	1000 100	800 80	1200 120	1200 120	1100 110
Coercive Force	oersted A/m	H_c	7.0 560	3.5 280	1.8 144	0.60 48	0.45 36
Loss Factor @ Frequency	10^{-6} MHz	$\tan \delta/\mu_i$	500 100	150 50	30 1.0	40 1.0	125 1.0
Temperature Coefficient of Initial Permeability (20-70 °C)	%/°C		0.10	0.05	0.10	0.8	0.75
Curie Temperature	°C	T_c	>500	>475	>350	>170	>160
Resistivity	Ω cm	ρ	$1x10^7$	$1x10^7$	$1x10^8$	$1x10^9$	$1x10^9$
Power Loss Density 25kHz - 2000 G - 100°C 100kHz - 1000 G - 100°C	mW/cm^3	P	– –	– –	– –	– –	– –
Recommended Frequency Range	MHz						
Application Areas: Low flux density devices.			<400	<300	<100	–	–
Application Areas: EMI suppression.			–	–	>200	<1000	20-250
Application Areas: Power magnetics.			–	–	–	–	–
Application Areas: Special square loop ferrite.			–	–	–	–	–
See this page for additional material data			6	7	8	9	10

42 Material, specifically developed for absorber applications in anechoic chambers, is listed on page 126.

** New Fair-Rite material, added in this edition of the catalog.*

Additional ferrite mechanical and thermal characteristics are tabulated on page 159.

Magnetic Properties of Ferrite Materials

33	**43**	**85**	**31***	**77**	**78**	**73**	**75**	**76**
600	850	900	1500	2000	2300	2500	5000	10000
2800 280 5 400	2900 290 10 800	4200 420 10 800	3400 340 5 400	4900 490 5 400	4800 480 5 400	3900 390 5 400	4300 430 5 400	4000 400 5 400
1200 120	1300 130	3700 370	2500 250	1800 180	1500 150	1500 150	1400 140	1800 180
0.60 48	0.45 36	0.50 40	0.35 28	0.30 24	0.20 16	0.24 19.2	0.16 13	0.12 9.6
25 0.2	250 1.0	30 0.1	20 0.1	15 0.1	4.5 0.1	10 0.1	15 0.1	15 0.025
0.10	1.25	–	1.6	0.7	1.0	0.65	0.6	0.5
>150	>130	>200	>130	>200	>200	>160	>140	>120
$1x10^{2}$	$1x10^{5}$	$2x10^{2}$	$3x10^{3}$	$1x10^{2}$	$2x10^{2}$	$1x10^{2}$	$3x10^{2}$	50
– –	– –	– –	– –	200 –	<115 <130	– –	140 –	– –
<3 – – –	<10 20-250 – –	– – – <0.15	– <500 – –	<3 – <0.1 –	<2.5 – <0.5 –	– <30 – –	<0.75 – <0.1 –	<0.5 – – –
11	12	13	14	16	18	20	21	22

68 Material

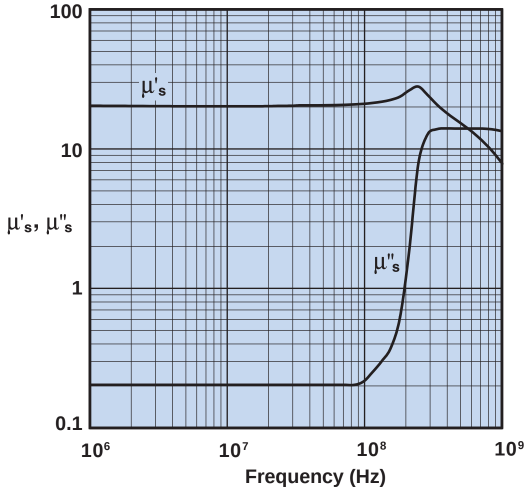
Our highest frequency NiZn ferrite intended for broadband transformers, antennas and HF high Q inductor applications up to 100 MHz. This material is only supplied to customer-specific requirements and close consultation with our application staff is suggested.

Strong magnetic fields or excessive mechanical stresses may result in irreversible changes in permeability and losses.

68 Material Specifications:

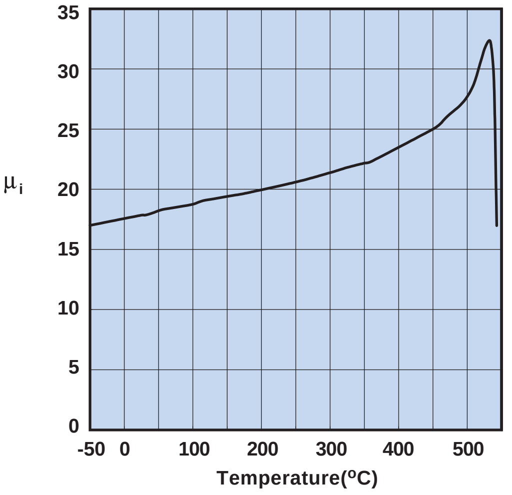
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	20
Flux Density @ Field Strength	gauss oersted	B H	2700 40
Residual Flux Density	gauss	B_r	1000
Coercive Force	oersted	H_c	7.0
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	500 100
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		0.10
Curie Temperature	°C	T_c	>500
Resistivity	Ω cm	ρ	1×10^7

Complex Permeability vs. Frequency



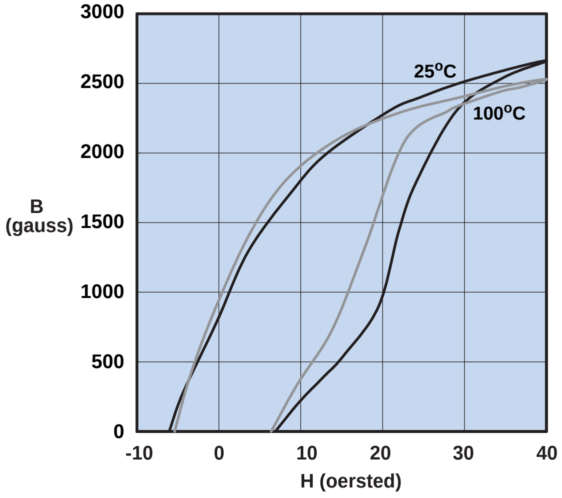
Measured on an 18/10/6mm toroid using the HP 4284A and the HP 4291A.

Initial Permeability vs. Temperature



Measured on an 18/10/6mm toroid at 100kHz.

Hysteresis Loop



Measured on an 18/10/6mm toroid at 10kHz.

67 Material

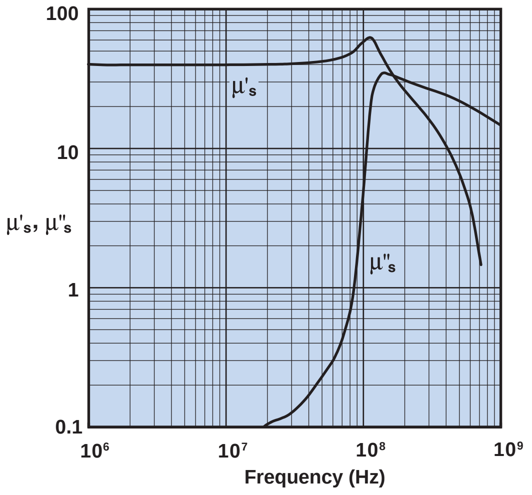
A high frequency NiZn ferrite for the design of broadband transformers, antennas and HF, high Q inductor applications up to 50 MHz. This material is only supplied to customer-specific requirements and close consultation with our application staff is suggested.

Strong magnetic fields or excessive mechanical stresses may result in irreversible changes in permeability and losses.

67 Material Specifications:

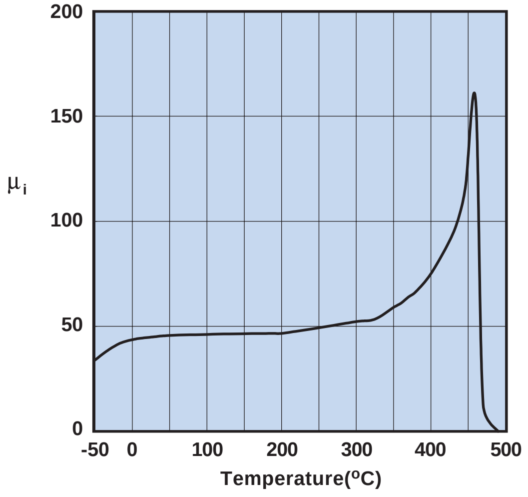
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	40
Flux Density	gauss	B	2300
@ Field Strength	oersted	H	20
Residual Flux Density	gauss	B_r	800
Coercive Force	oersted	H_c	3.5
Loss Factor	10^{-6}	$\tan\delta/\mu_i$	150
@ Frequency	MHz		50
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		0.05
Curie Temperature	°C	T_c	>475
Resistivity	Ω cm	ρ	$1x10^7$

Complex Permeability vs. Frequency



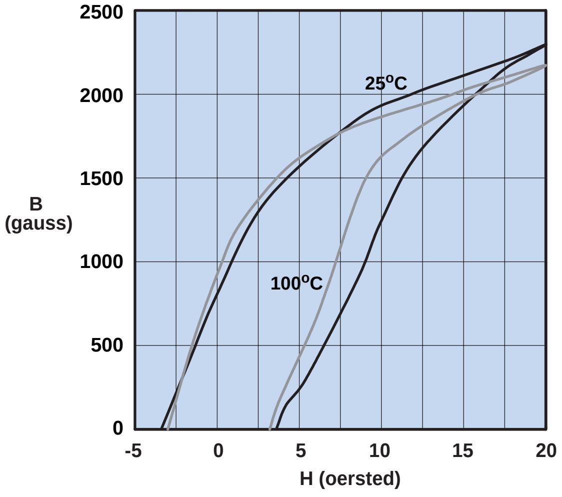
Measured on an 19/10/6mm toroid using the HP 4284A and the HP 4291A.

Initial Permeability vs. Temperature



Measured on a 19/10/6mm toroid at 100kHz.

Hysteresis Loop



Measured on a 19/10/6mm toroid at 10kHz.

61 Material

A high frequency NiZn ferrite developed for a range of inductive applications up to 25 MHz. This material is also used in EMI applications for suppression of noise frequencies above 200 MHz.

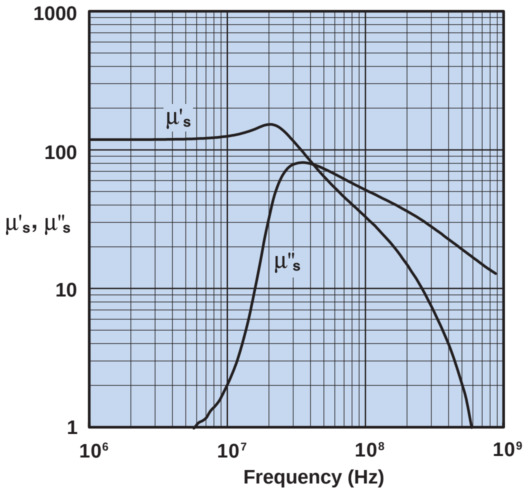
EMI suppression beads, beads on leads, SM beads, wound beads, multi-aperture cores, round cable EMI suppression cores, rods, RFID rods, and toroids are all available in 61 material.

Strong magnetic fields or excessive mechanical stresses may result in irreversible changes in permeability and losses.

61 Material Specifications:

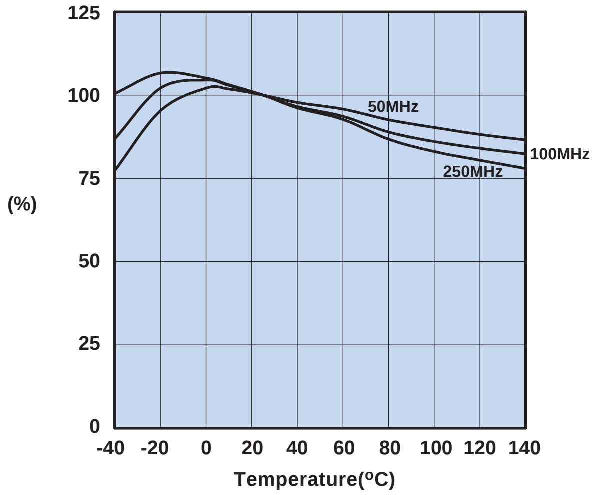
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	125
Flux Density	gauss	B	2350
@ Field Strength	oersted	H	15
Residual Flux Density	gauss	B_r	1200
Coercive Force	oersted	H_c	1.8
Loss Factor	10^{-6}	$\tan\delta/\mu_i$	30
@ Frequency	MHz		1.0
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		0.10
Curie Temperature	°C	T_c	>350
Resistivity	Ω cm	ρ	1×10^8

Complex Permeability vs. Frequency



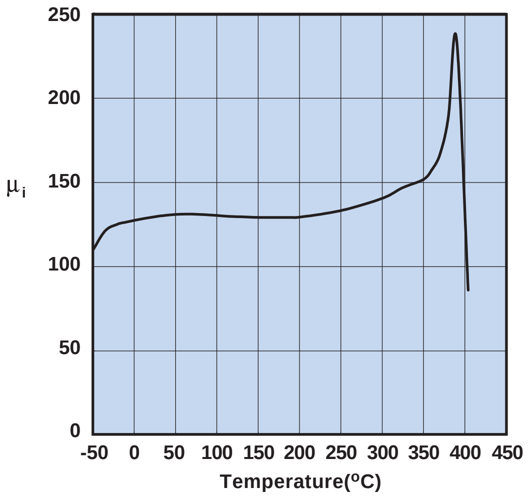
Measured on a 19/10/6mm toroid using the HP 4284A and the HP 4291A.

Percent of Original Impedance vs. Temperature



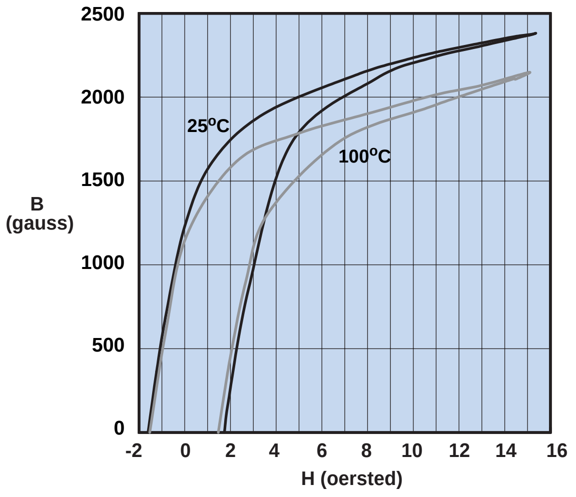
Measured on a 2661000301 using the HP4291A.

Initial Permeability vs. Temperature



Measured on a 19/10/6mm toroid at 100kHz.

Hysteresis Loop



Measured on a 19/10/6mm toroid at 10kHz.

43 Material

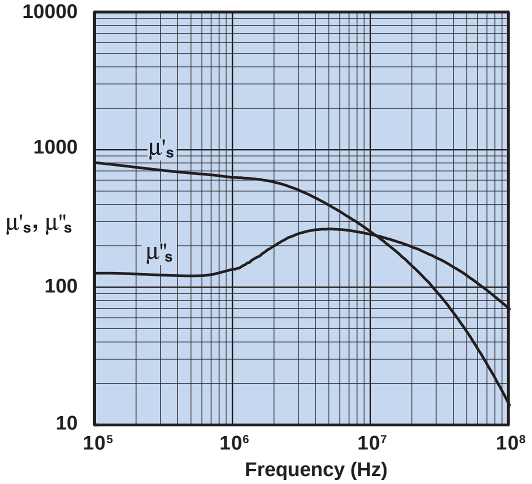
This NiZn is our most popular ferrite for suppression of conducted EMI from 20 MHz to 250 MHz. This material is also used for inductive applications such as high frequency common-mode chokes.

EMI suppression beads, beads on leads, SM beads, multi-aperture cores, round cable EMI suppression cores, split round EMI suppression cores, round cable snap-its, flat cable EMI suppression cores, flat cable snap-its, miscellaneous suppression cores, bobbins, and toroids are all available in 43 material.

43 Material Specifications:

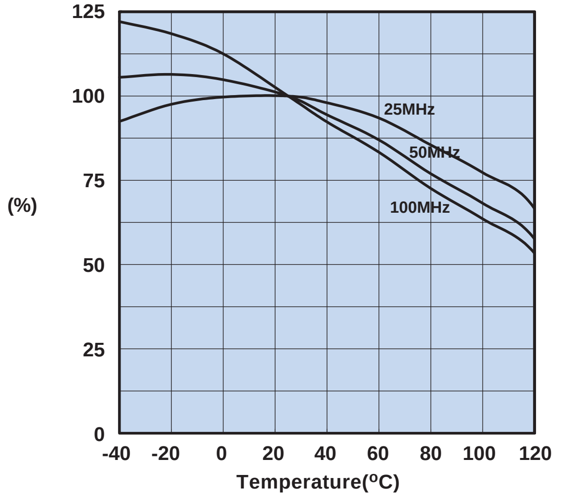
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	850
Flux Density @ Field Strength	gauss oersted	B H	2900 10
Residual Flux Density	gauss	B_r	1300
Coercive Force	oersted	H_c	0.45
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	250 1.0
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		1.25
Curie Temperature	°C	T_c	>130
Resistivity	Ω cm	ρ	$1\text{x}10^5$

Complex Permeability vs. Frequency



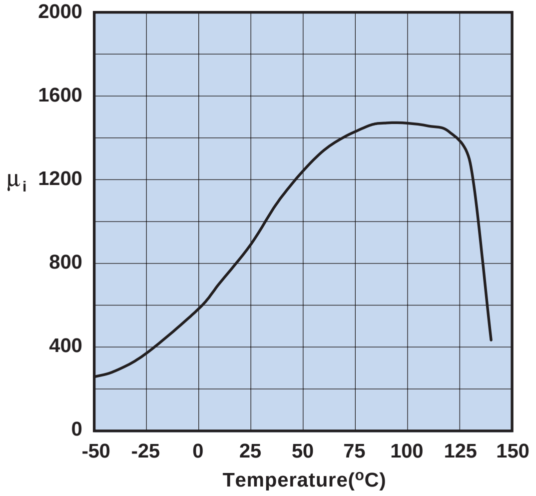
Measured on a 17/10/6mm toroid using the HP 4284A and the HP 4291A.

Percent of Original Impedance vs. Temperature



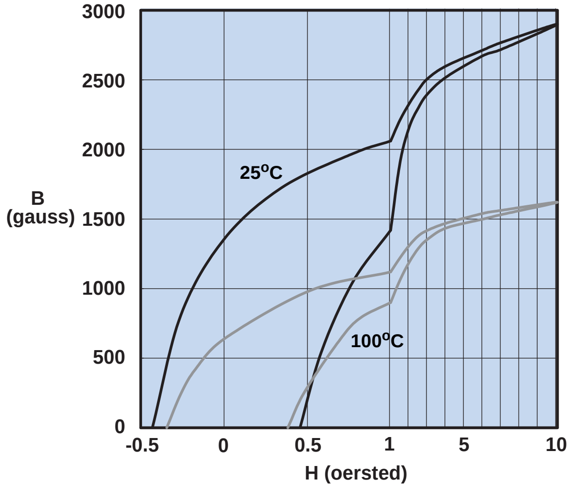
Measured on a 2643000301 using the HP4291A.

Initial Permeability vs. Temperature



Measured on a 17/10/6mm toroid at 100kHz.

Hysteresis Loop



Measured on a 17/10/6mm toroid at 10kHz.

31 Material

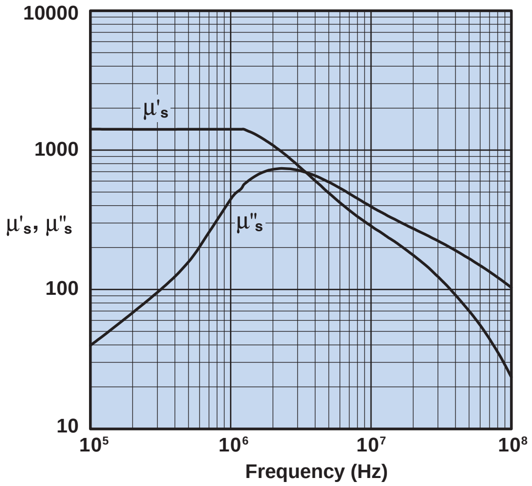
A new MnZn ferrite designed specifically for EMI suppression applications from as low as 1 MHz up to 500 MHz. This material does not have the dimensional resonance limitations associated with conventional MnZn ferrite materials.

EMI suppression beads, round cable EMI suppression cores, round cable snap-its, flat cable EMI suppression cores, and flat cable snap-its are all available in 31 material.

31 Material Specifications:

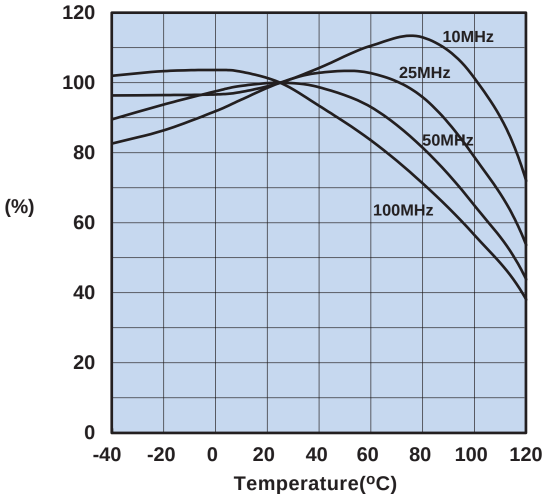
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	1500
Flux Density @ Field Strength	gauss oersted	B H	3400 5
Residual Flux Density	gauss	B_r	2500
Coercive Force	oersted	H_c	0.35
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	20 0.1
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		1.6
Curie Temperature	°C	T_c	>130
Resistivity	Ω cm	ρ	$3x10^3$

Complex Permeability vs. Frequency



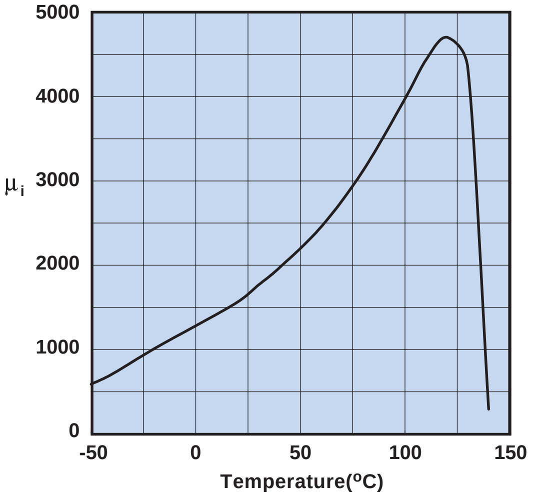
Measured on a 17/10/6mm toroid at 25°C using the HP 4284A and the HP 4291A.

Percent of Original Impedance vs. Temperature



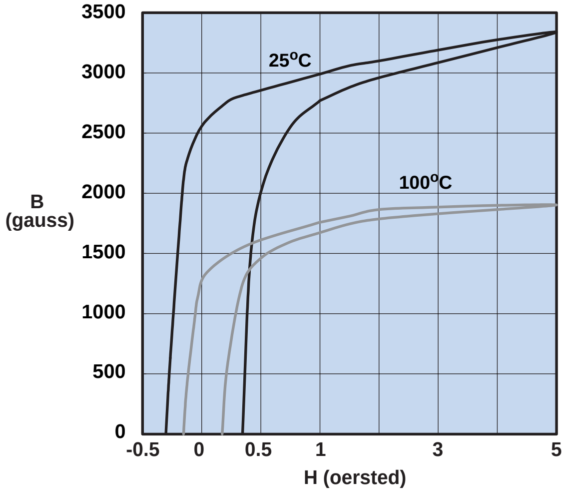
Measured on a 2631000301 using the HP4291A.

Initial Permeability vs. Temperature



Measured on a 17/10/6mm toroid at 100kHz.

Hysteresis Loop



Measured on a 17/10/6mm toroid at 10kHz.

77 Material

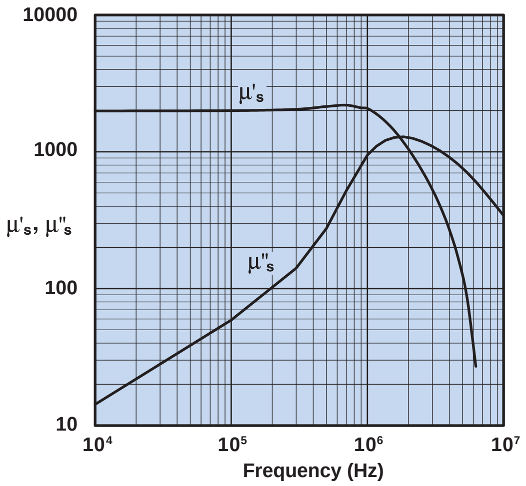
A MnZn ferrite for use in a wide range of high and low flux density inductive designs for frequencies up to 100 kHz.

Pot cores, EP cores, PQ cores, ETD cores, E&I cores, U cores, rods, tack bobbin cores, toroids, and bobbins are all available in 77 material.

77 Material Specifications:

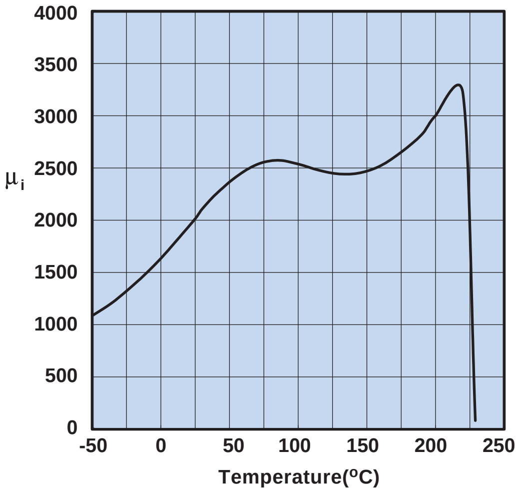
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	2000
Flux Density @ Field Strength	gauss oersted	B H	4900 5
Residual Flux Density	gauss	B_r	1800
Coercive Force	oersted	H_c	0.30
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	15 0.1
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		0.7
Curie Temperature	°C	T_c	>200
Resistivity	Ω cm	ρ	$1x10^2$

Complex Permeability vs. Frequency



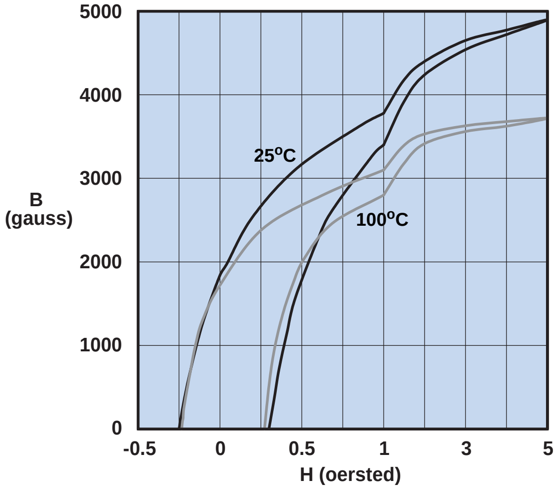
Measured on an 18/10/6mm toroid
using the HP 4284A and the HP 4291A.

Initial Permeability vs. Temperature



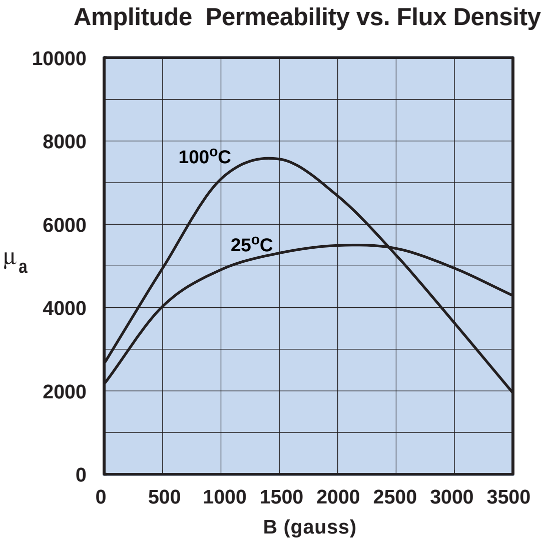
Measured on an 18/10/6mm toroid at 100kHz.

Hysteresis Loop

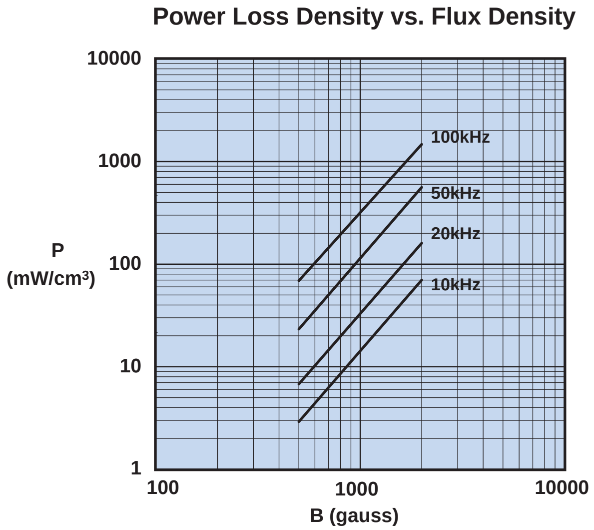


Measured on an 18/10/6mm toroid at 10kHz.

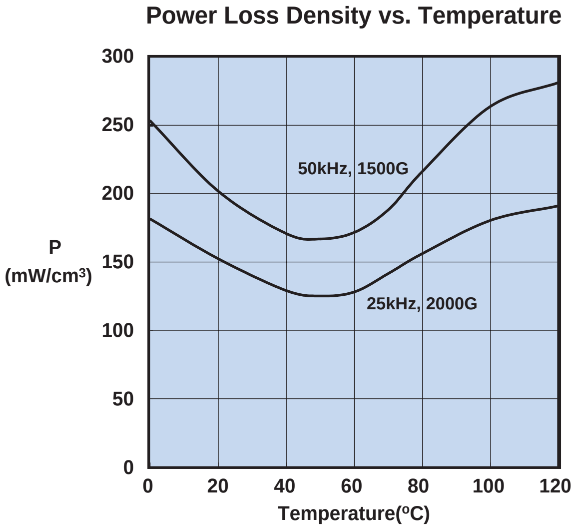
77 Material



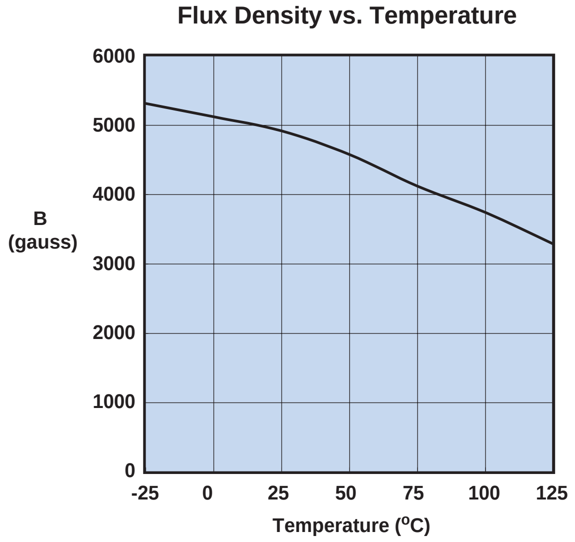
Measured on an 18/10/6mm toroid at 10kHz.



Measured on an 18/10/6mm toroid using the Clarke Hess 258 VAW at 100°C



Measured on an 18/10/6mm toroid using the Clarke Hess 258 VAW.



Measured on an 18/10/6mm toroid at 10kHz and H=5 oersted.

78 Material

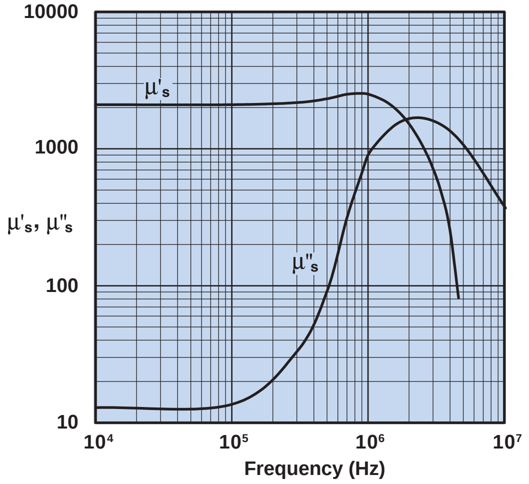
A MnZn ferrite specifically designed for power applications for frequencies up to 200 kHz.

RFID rods, toroids, pot cores, EP cores, PQ cores, ETD cores, U cores, and E&I cores are all available in 78 material.

78 Material Specifications:

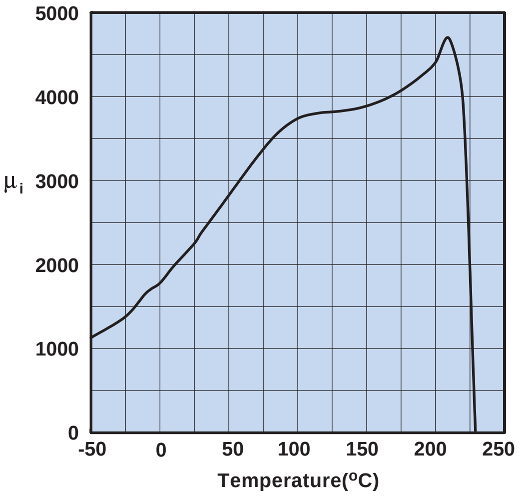
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	2300
Flux Density	gauss	B	4800
@ Field Strength	oersted	H	5
Residual Flux Density	gauss	B_r	1500
Coercive Force	oersted	H_c	0.20
Loss Factor	10^{-6}	$\tan\delta/\mu_i$	4.5
@ Frequency	MHz		0.1
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		1.0
Curie Temperature	°C	T_c	>200
Resistivity	Ω cm	ρ	$2x10^2$

Complex Permeability vs. Frequency



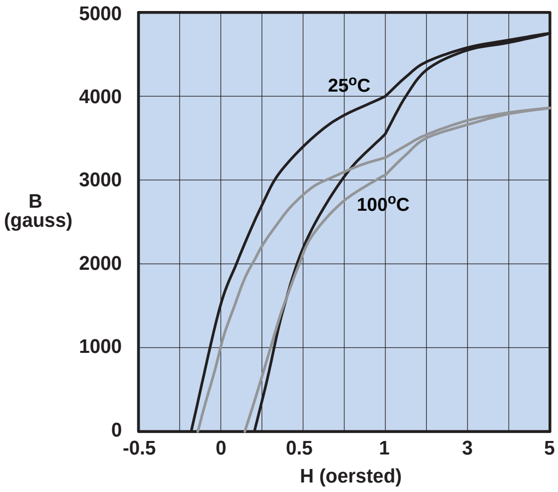
Measured on an 18/10/6mm toroid using the HP 4284A and the HP 4291A.

Initial Permeability vs. Temperature



Measured on an 18/10/6mm toroid at 100kHz.

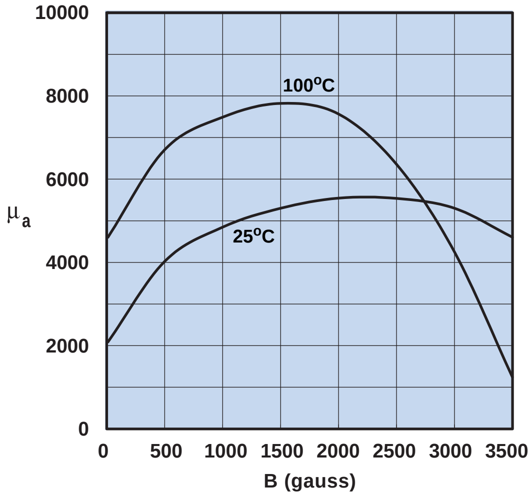
Hysteresis Loop



Measured on an 18/10/6mm toroid at 10kHz.

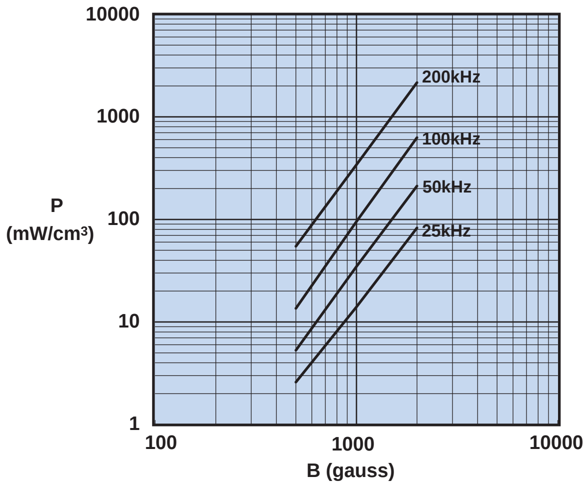
78 Material

Amplitude Permeability vs. Flux Density



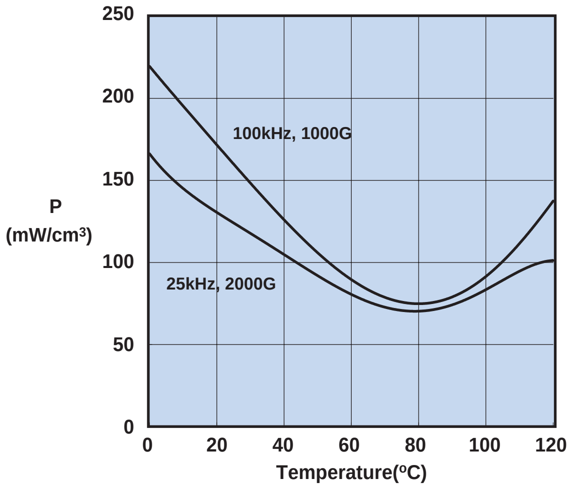
Measured on an 18/10/6mm toroid at 10kHz.

Power Loss Density vs. Flux Density



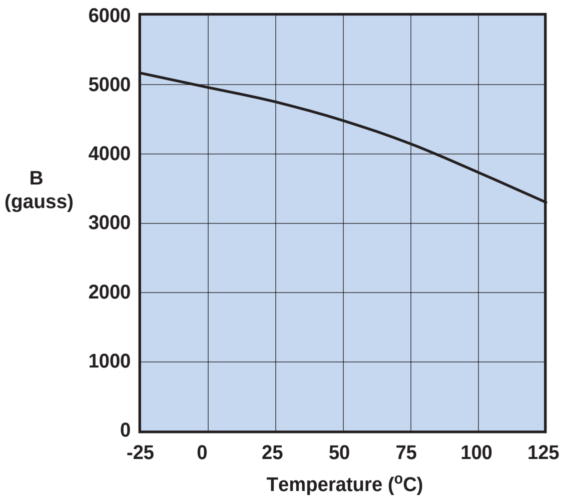
Measured on an 18/10/6mm toroid using the Clarke Hess 258 VAW at 100°C

Power Loss Density vs. Temperature



Measured on an 18/10/6mm toroid using the Clarke Hess 258 VAW.

Flux Density vs. Temperature



Measured on an 18/10/6 mm toroid at 10kHz and H=5 oersted.

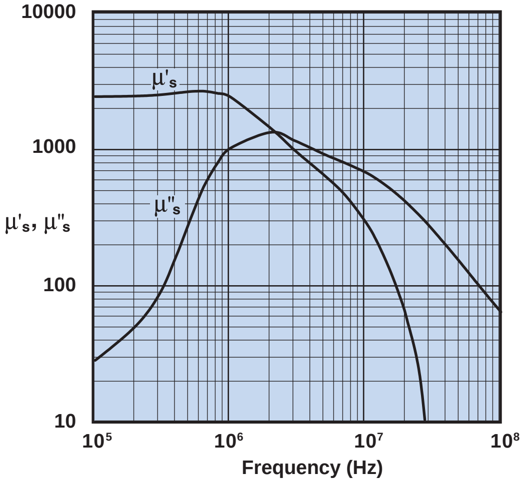
73 Material

A MnZn ferrite, supplied only in small cores, to suppress conducted EMI frequencies below 30 MHz.

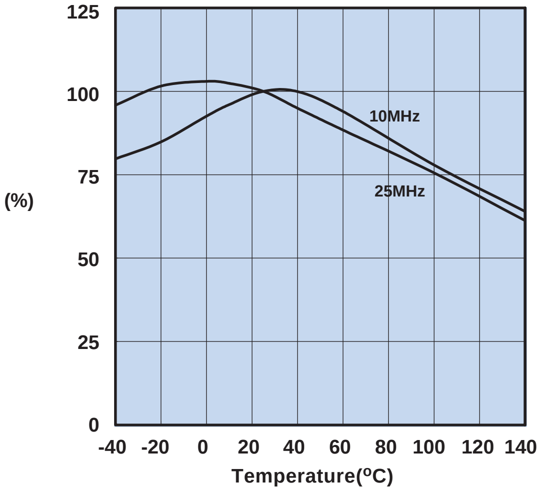
EMI suppression beads, beads on leads, SM beads, and multi-aperture cores are all available in 73 material.

73 Material Specifications:

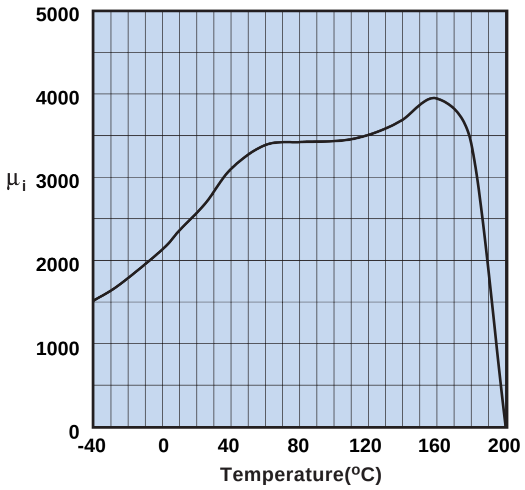
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	2500
Flux Density @ Field Strength	gauss oersted	B H	3900 5
Residual Flux Density	gauss	B_r	1500
Coercive Force	oersted	H_c	0.24
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	10 0.1
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		0.65
Curie Temperature	°C	T_c	>160
Resistivity	Ω cm	ρ	$1x10^2$


Complex Permeability vs. Frequency

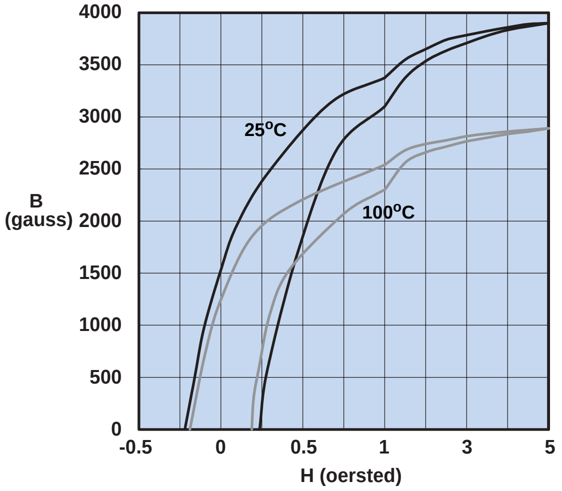
Measured on a 2673000301 bead using the HP 4284A and the HP 4291A.


Percent of Original Impedance vs. Temperature

Measured on a 2673000301 using the HP4291A.


Initial Permeability vs. Temperature

Measured on a 17/10/6mm toroid at 10kHz.


Hysteresis Loop

Measured on a 17/10/6mm toroid at 10kHz.

75 Material

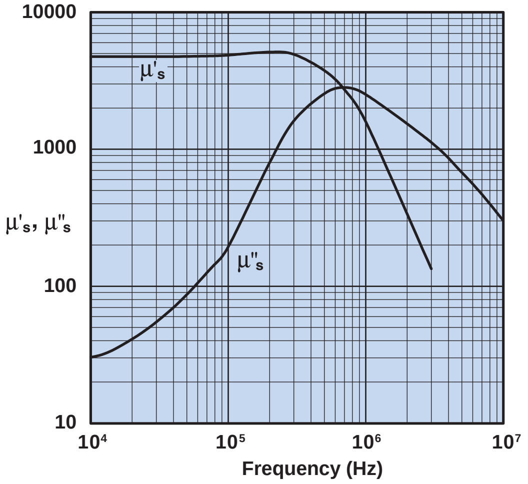
A high permeability MnZn ferrite intended for a range of broadband and pulse transformer applications and common-mode inductor designs.

Toroids, E&I cores, and EP cores are all available in 75 material.

75 Material Specifications:

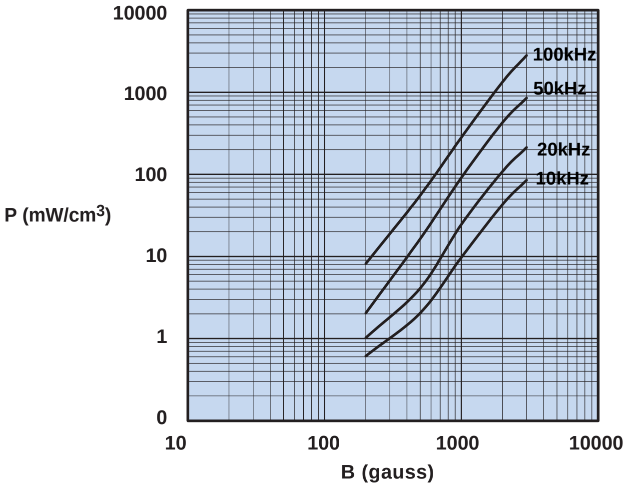
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	5000
Flux Density @ Field Strength	gauss oersted	B H	4300 5
Residual Flux Density	gauss	B_r	1400
Coercive Force	oersted	H_c	0.16
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	15 0.1
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		0.6
Curie Temperature	°C	T_c	>140
Resistivity	Ω cm	ρ	$3\text{x}10^2$

Complex Permeability vs. Frequency



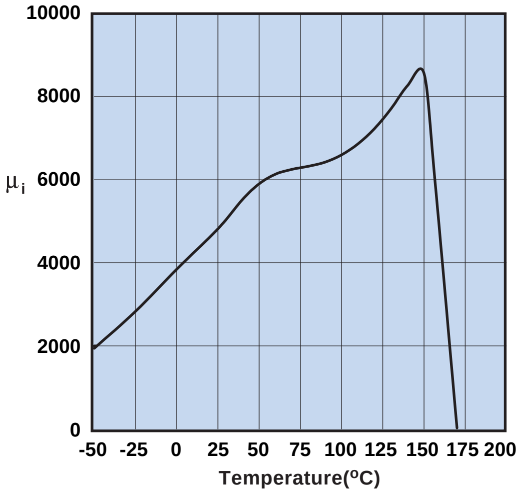
Measured on a 17/10/6mm toroid using the HP 4284A and the HP 4291A.

Power Loss Density vs. Flux Density



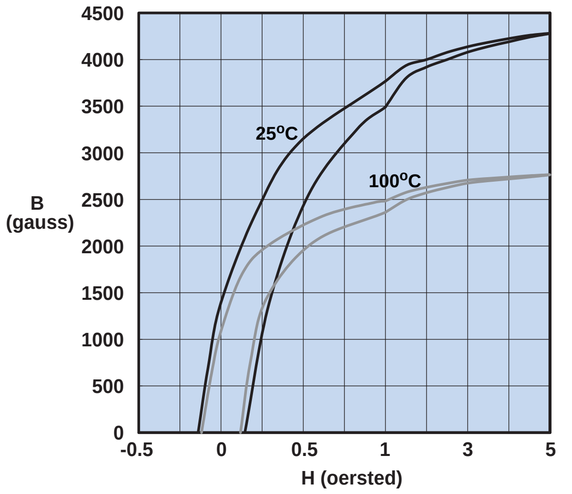
Measured on a 17/10/6mm toroid using the Clarke Hess 258 VAW at 100°C.

Initial Permeability vs. Temperature



Measured on a 17/10/6mm toroid at 10kHz.

Hysteresis Loop



Measured on a 17/10/6mm toroid at 10kHz.

76 Material

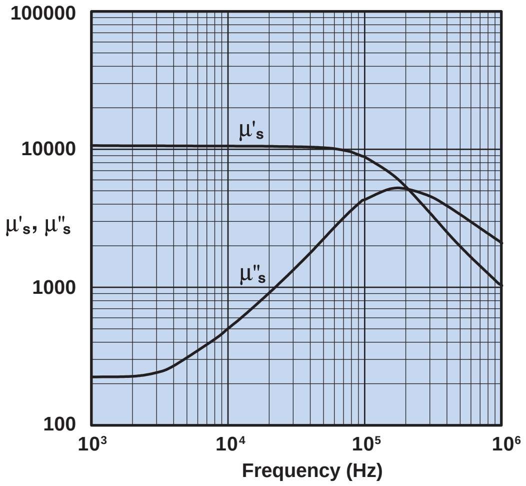
A MnZn ferrite with a 10K permeability and an acceptable Curie temperature for broadband and pulse transformer designs and common-mode choke applications.

Toroids are available in 76 material.

76 Material Specifications:

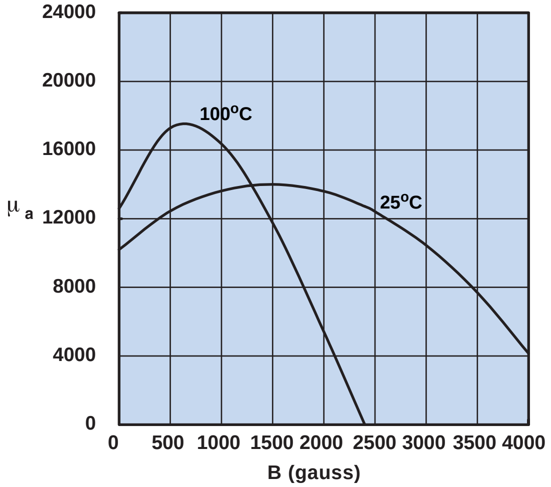
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	10000
Flux Density @ Field Strength	gauss oersted	B H	4000 5
Residual Flux Density	gauss	B_r	1800
Coercive Force	oersted	H_c	0.12
Loss Factor @ Frequency	10^{-6} MHz	$\tan\delta/\mu_i$	15 0.025
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		0.5
Curie Temperature	°C	T_c	>120
Resistivity	Ω cm	ρ	50

Complex Permeability vs. Frequency



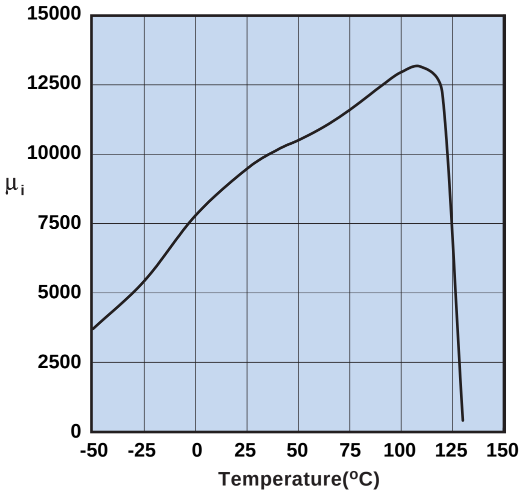
Measured on a 17/10/6mm toroid
using the HP 4284A and, the HP 4291A.

Amplitude Permeability vs. Flux Density



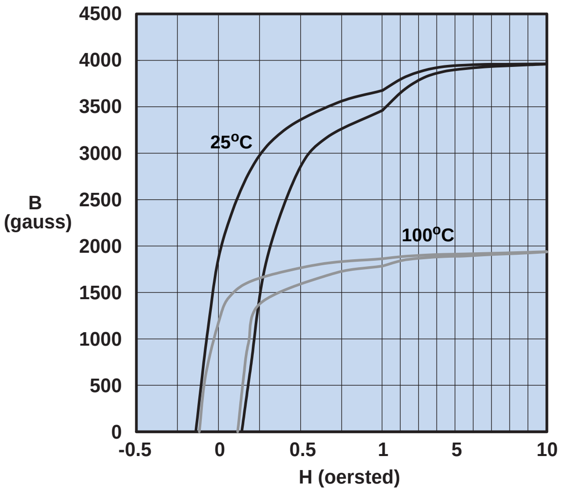
Measured on a 17/10/6mm toroid
using the HP 54510A.

Initial Permeability vs. Temperature



Measured on a 17/10/6mm toroid at 10kHz.

Hysteresis Loop



Measured on a 17/10/6mm toroid at 10kHz.