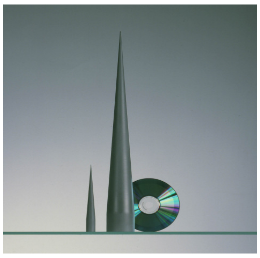
Eccosorb®MF

Lossy, Magnetically Loaded, Machinable Stock



LOSSY, MAGNETICALLY LOADED, MACHINABLE STOCK

Eccosorb MF is a series of rigid magnetically loaded epoxy stock, which can be machined for use as absorbers, attenuators and terminations in waveguides, coaxial or stripline applications. With products such as these, it is necessary to be conversant with the dielectric and magnetic properties of the materials, which are listed in this technical bulletin, the values given are normalized with respect to free space, see Typical Electrical Properties table.

FEATURES AND BENEFITS

- Rigid
- Machinable

MARKETS

- Commercial Telecom
- Security and Defense

SPECIFICATIONS

TYPICAL PROPERTIES	ECCOSORB MF
Frequency Range	>1 GHz
Service Temperature °C (°F)	<180 (<356)
Density g/cc	1.6 – 4.9
Hardness, Shore D	85
Tensile Strength (MPa)	55
Thermal Expansion per °C	~30 x 10^{-6}
Water Absorption, % 24 hours	<0.3
Thermal Conductivity W/mK	1.44

Data for design engineer guidance only. Observed performance varies in application. Engineers are reminded to test the material in application.

APPLICATIONS

- Eccosorb MF is widely used as absorbers, attenuators, and terminations in waveguides and coaxial lines.
- It has also been successfully used as a high-Q inductor-core material in such devices as slug tuners. It is also useful in many other magnetic components.
- Simple RF filters can be formed by passing filament leads through small blocks of Eccosorb MF, or by casting appropriate sections of the material around such leads by using one of the electrically equivalent castable absorbers.
- There are also applications in antenna elements and in certain free-space absorbers.

For assistance in termination design, see Termination Design Considerations.

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AVAILABILITY

- Eccosorb MF is available in the following standard stock sizes :
- Sheets 30.5 cm x 30.5 cm (12” x 12”) in thicknesses of 0.32, 0.64, 0.95, 1.27, 1.59, 1.91, 2.54, 3.81, 5.08, 6.35, 7.62 cm (1/8, 1/4, 3/8, 1/2, 5/8, 3/4, 1.0, 1.5, 2.0, 2.5 & 3.0”).
- Rods 30.5 cm long (12”) in diameters of 0.32, 0.64, 0.95, 1.27, 1.59, 1.91, 2.54, 3.81, 5.08, 6.35, 7.62 cm. (1/8, 1/4, 3/8, 1/2, 5/8, 3/4, 1.0, 1.5, 2.0, 2.5 & 3.0”)
- Bars 30.5 cm long (12”) in squares of 0.64, 0.95, 1.27, 1.59, 1.91, 2.54, 3.81, 5.08 cm (1/4, 3/8, 1/2, 5/8, 3/4, 1.0, 1.5 & 2.0”).
- Other sizes, shapes, thicknesses, and configurations are available on special order.
- In some cases, depending on which Eccosorb MF series is being used, casting of certain configurations can be done during manufacturing as shown below.

INSTRUCTIONS FOR USE

Termination Design Considerations :

- The most widely used member of the Eccosorb MF series is MF-117. It is an excellent material to start experimentation. Most designs of terminating and attenuating elements depend heavily upon cut-and-try procedures. A preliminary design is established by experience or rough estimates of probably satisfactory dimensions, a piece of Eccosorb MF is machined and tested for VSWR and/or attenuation and the design is then modified as required.
- In coaxial, waveguide and strip-line terminations, either step-tapered or uniformly tapered configurations can be used.
- Step-tapered terminations are narrow-banded and highly critical dimensionally. They are recommended only where essentially single frequency operation is anticipated. Increasing the number of steps beyond two can increase the usable band-width and such designs are helpful when limited length is available in the direction of propagation. Reproducibility of the performance of step-tapered terminations may be difficult because of their sensitivity to small changes in magnetic and dielectric properties.
- Uniformly tapered terminations are generally preferred because of the low VSWR which is possible to achieve over a wide frequency range. Dimensions are reasonably non-critical and performance is reasonably insensitive to magnetic and dielectric properties. In general, the more gradual the taper, the lower the VSWR. A length-to-base-width ratio of 10:1 is highly desirable for VSWR as low as 1.01 over a full waveguide frequency band, particularly with materials having the higher values of M' and K'. A sufficiently long taper must be used so that very little energy reaches the base mounting plate where it can be reflected back into the line. The one-way attenuation should be at least 25 dB for VSWR as low as 1.01.
- Wall-type uniform tapers offer maximum heat-transfer efficiency and are recommended for high-power applications.

RELATED PRODUCTS

- For higher temperature applications up to 260 °C, refer to the electrical equivalent Eccosorb® MF500F.

TYPICAL ELECTRICAL PROPERTIES

E-M PROPERTIES OF ECCOSORB MF

		Frequency Hz							Frequency GHz				
		10^2	10^3	10^4	10^5	10^6	10^7	10^8	1.0	3.0	8.6	10.0	18.0
MF-110	K'	18	16	15	13	11	9.0	7.0	5.0	3.2	3.0	2.9	2.8
	$\tan\delta_d$	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.04	0.04
	K''	0.18	0.16	0.30	0.26	0.33	0.27	0.28	0.20	0.16	0.15	0.12	0.11
	M'	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.0	1.0	1.0
	$\tan\delta_m$	0	0	0	0	0	0	0	0	0	0.10	0.10	0.20
	M''	0	0	0	0	0	0	0	0	0	0.10	0.10	0.20
	dB/cm	0	0	0	0	0	0	0.01	0.09	0.26	2.0	2.2	6.6
	$\|Z\|/Z_0$	0.26	0.27	0.28	0.30	0.33	0.37	0.40	0.47	0.59	0.59	0.59	0.60
MF-112	K'	20	18	16	14	12	10	8	6	5.2	5.0	4.8	4.6
	$\tan\delta_d$	0.02	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.04	0.03
	K''	0.40	0.36	0.48	0.42	0.36	0.40	0.32	0.24	0.26	0.25	0.19	0.14
	M'	2.0	1.9	1.8	1.7	1.6	1.5	1.5	1.4	1.4	1.1	1.1	1.0
	$\tan\delta_m$	0	0	0	0	0	0	0.01	0.02	0.03	0.22	0.23	0.26
	M''	0	0	0	0	0	0	0.02	0.03	0.04	0.24	0.25	0.26
	dB/cm	0	0	0	0	0	0	0.02	0.16	0.59	4.9	5.6	10.1
	$\|Z\|/Z_0$	0.32	0.32	0.34	0.35	0.37	0.39	0.43	0.48	0.52	0.47	0.48	0.47
MF-114	K'	22	21	19	18	16	14	12	11	9.9	9.8	9.7	9.6
	$\tan\delta_d$	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.05
	K''	0.88	0.84	0.76	0.72	0.80	0.70	0.60	0.55	0.59	0.59	0.49	0.48
	M'	2.8	2.8	2.7	2.6	2.5	2.4	2.3	2.1	1.9	1.3	1.1	1.0
	$\tan\delta_m$	0	0	0	0	0	0	0.04	0.08	0.13	0.33	0.40	0.45
	M''	0	0	0	0	0	0	0.09	0.17	0.25	0.43	0.44	0.45
	dB/cm	0	0	0	0	0	0	0.04	0.57	2.2	10.8	13.2	24.9
	$\|Z\|/Z_0$	0.36	0.37	0.38	0.38	0.40	0.41	0.44	0.57	0.44	0.37	0.35	0.34
MF-116	K'	40	35	30	26	23	20	18	17	16.5	16.2	16.0	15.8
	$\tan\delta_d$	0.06	0.06	0.07	0.07	0.08	0.09	0.08	0.07	0.06	0.07	0.06	0.05
	K''	2.4	2.1	2.1	1.8	1.8	1.8	1.4	1.2	0.99	1.1	0.96	0.79
	M'	4.6	4.5	4.4	4.4	4.3	4.2	4.0	3.0	2.8	1.6	1.5	1.4
	$\tan\delta_m$	0	0	0	0	0	0	0.04	0.13	0.21	0.47	0.68	0.73
	M''	0	0	0	0	0	0	0.16	0.39	0.59	0.75	1.02	1.02
	dB/cm	0	0	0	0	0	0	0.09	1.3	5.0	21	32	57
	$\|Z\|/Z_0$	0.34	0.36	0.38	0.41	0.43	0.46	0.47	0.42	0.42	0.33	0.33	0.33
MF-117	K'	195	158	120	85	62	48	38	28	22.9	21.4	21	20.6
	$\tan\delta_d$	0.18	0.21	0.23	0.24	0.22	0.18	0.12	0.09	0.06	0.02	0.02	0.02
	K''	35	33	28	20	14	8.6	4.6	2.5	1.4	0.42	0.42	0.41
	M'	5.0	5.0	5.0	5.0	5.0	5.0	4.8	4.1	3.4	1.2	1.1	1.0
	$\tan\delta_m$	0	0	0	0	0	0	0.1	0.20	0.39	1.36	1.5	2.00
	M''	0	0	0	0	0	0	0.48	0.82	1.33	1.63	1.7	2.00
	dB/cm	0	0	0	0	0	0.03	0.27	2.8	11.0	46	56	119
	$\|Z\|/Z_0$	0.16	0.18	0.20	0.24	0.28	0.32	0.36	0.39	0.40	0.30	0.31	0.33
MF-124	K'	260	205	145	95	70	52	40	32	25.8	23.8	23.6	23.0
	$\tan\delta_d$	0.40	0.39	0.36	0.31	0.26	0.20	0.14	0.08	0.07	0.05	0.03	0.04
	K''	104	80	52	29	18	10	5.6	2.6	1.8	1.19	0.71	0.92
	M'	7.0	6.9	6.8	6.7	6.6	6.3	6.0	5.0	3.8	2.50	1.5	1.0
	$\tan\delta_m$	0	0	0	0	0	0	0.2	0.45	0.69	1.10	1.4	2.5
	M''	0	0	0	0	0	0	1.2	2.3	2.62	2.75	2.1	2.5
	dB/cm	0	0	0	0	0	0.03	0.48	6.5	20	63	67	149
	$\|Z\|/Z_0$	0.16	0.18	0.21	0.26	0.30	0.34	0.39	0.42	0.42	0.39	0.33	0.34
MF-175	K'	320	250	170	105	78	56	42	36	27.0	25.0	24.0	24.0
	$\tan\delta_d$	0.50	0.49	0.46	0.41	0.36	0.26	0.16	0.06	0.05	0.03	0.02	0.02
	K''	160	123	78	43	28	15	6.7	2.2	1.35	0.75	0.48	0.48
	M'	8.0	7.9	7.8	7.7	7.6	7.3	7.0	6.0	4.4	1.80	1.3	1.1
	$\tan\delta_m$	0	0	0	0	0	0	0.4	0.6	0.8	1.40	1.6	3.0
	M''	0	0	0	0	0	0	2.8	3.6	3.52	2.5	2.1	3.3
	dB/cm	0	0	0	0	0.01	0.05	0.87	8.6	24	65	69	177
	$\|Z\|/Z_0$	0.15	0.17	0.20	0.26	0.30	0.36	0.42	0.44	0.46	0.35	0.32	0.38
MF-190	K'	380	295	195	115	86	60	44	40	28.0	26.0	25.0	25.0
	$\tan\delta_d$	0.60	0.59	0.56	0.51	0.46	0.32	0.18	0.07	0.04	0.04	0.02	0.02
	K''	228	174	109	59	40	19	7.9	2.8	1.12	1.04	0.50	0.50
	M'	9.0	8.9	8.8	8.7	8.6	8.3	8.0	7.0	4.5	2.0	1.5	1.1
	$\tan\delta_m$	0	0	0	0	0	0	0.6	0.8	0.9	1.40	1.6	4.0
	M''	0	0	0	0	0	0	4.0	5.6	4.05	2.8	2.4	4.4
	dB/cm	0	0	0	0	0.01	0.06	1.3	12.6	27	70	75	217
	$\|Z\|/Z_0$	0.14	0.16	0.20	0.26	0.30	0.36	0.46	0.47	0.47	0.36	0.34	0.43

Legend

K'	Real part of the permittivity (dielectric constant)
tan δ_d	Dielectric loss tangent
K"	Imaginary part of the permittivity (loss)
M'	Real part of the magnetic permeability
tan δ_m	Magnetic loss tangent
M"	Imaginary part of the magnetic permeability (loss)
dB/cm	Attenuation per unit distance
dB/in	Attenuation per unit distance
lZl/Z_0	Normalized impedance magnitude ratio

Most of the definitions and equations are included in the Laird publication :"**ENERGY PROPAGATION IN DIELECTRIC AND MAGNETIC MATERIALS**." A copy of this publication can be requested.

In this technical bulletin, µ' is used for the real part of the magnetic permeability and µ" for the magnetic loss factor. Beyond the definitions in the publication above, the clarification of the terms dB/cm (attenuation) and |Z|/Zo (relative impedance) are offered.

These characteristics are not in themselves directly applicable to the calculation of transmission and reflection coefficients as they are defined on point 3 & 4 of "Energy Propagation in Dielectric and Magnetic Material". For these calculations, the complex dielectric constant (K'-jK' Tan δ_d) and complex magnetic permeability (M'-jM' Tan δ_m) are used as listed in the table.

The definition of dB/unit length is included in the reference, both in mathematical form and in words. The value is useful in comparing one material against another to determine which offers the most loss independent of interface reflection coefficients. Similarly, |Z|/Zo, the normalized impedance magnitude ratio, can be used as a qualitative measure of the impedance match between free space and the material. An impedance ratio that is closest to 1 is the most desirable because at that ratio, the impedance match between the material and free space is perfect.

The significant features of the property tables are:

1. In every case, K' decreases with increasing frequency.
2 Almost without exception, the dielectric loss tangent and dielectric loss factor decrease with increasing frequency, the exception occurs at the low end of the frequency band, and can be ignored in most applications.
3.The magnetic loading increases from a minimum in MF-110 to a maximum in MF-190. There is a corresponding increase in K', K", µ', Tan δ_m and µ".
4.The 0 values in the table indicate that the number is less than 0.01.
5.The values given in the table are nominal values and should not be used by customers in the writing of procurement specifications.
If specifications are needed, the customer should consult with the Laird Sales Department.
The use of dielectric/magnetic properties for Quality Control, i.e., incoming or outgoing inspection, is not recommended, because the measurement of these properties is very time consuming and complicated. It is recommended to monitor the density.

MACHINING RECOMMENDATIONS

Most of the discussion below applies not only to the basic Eccosorb MF series of materials, but also to several high temperatures, castable and molding-powder equivalents. Eccosorb MF can be formed readily to close tolerances with standard metal-working machine tools, i.e.: lathes, milling machines, drills, saws, grinders, generally using conventional techniques but observing the precautions and limitations described below.

Tooling :

- For turning, milling, drilling and tapping, carbide tools should be used, for example Type 883, a general purpose carbide that works well under most conditions. Use solid carbide taps for long life. Standard size tap drills should be satisfactory.
- External threads are formed best, not with conventional thread-cutting dies but by lathe turning or grinding, with light feeds and shallow cuts.
- Sawing can be done with best finish and tolerance using circular saws, 20.3 to 25.4 cm diameter, with grinding coolant and high RPM. Thin carborandum wheels, 0,079 cm thick or carbide saws may be used where requirements are less stringent. Best results are attained by moving the saw and keeping work stationary, with saw rotating so it tends to climb into the work.
- Surface finishing of flat sheets, etc. is best performed with a Blanchard grinder. Eccosorb MF is held readily with magnetic chucks. Sheet size is limited by the size of the machine.

Coolants :

- Use of a coolant liquid is recommended, especially for all close tolerance operations. Commercial grinding fluid is preferred, or water-soluble oil, with rust-resisting properties to protect the machines. Spark producing operations in particular must not be run dry, since smoldering fires might result.
- Where coolant run-off is collected for recirculation, a two-cavity recovery system should be used to minimize pick-up of grinding dust, sawdust or chips by the coolant pump. Where a re-circulating system is not available, best results will be obtained with air-powered spray or mist equipment.

Use of tapped metal inserts should be considered where electrical performance will not be degraded. Inserts may be cast in place, or bonded with castable material of suitable composition.

Suggested Speeds and Feed Rates

The following speeds and feed rates are suggested to be modified as necessary to suit job conditions:

OPERATION	SPEED	FEED
Sawing, turning	21.3 - 27.4 m/min (70-90 ft/min)	0.13 - 0.20 mm .005-.008 in/revolution
External threading	21.3 - 27.4 m/min 70-90 ft/minute	0.038 mm/pass .001 in/pass
Tapping	450 rpm	Tapping Head
Milling	21.3 - 27.4 m/min. 70-90 ft/min	0.038 - 0.076 mm/tooth .0015-.003 in/tooth

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