ECCOSORB®MF-PP

Magnetically Loaded Thermoplastic Absorber

INJECTION MOLDABLE THERMOPLASTIC ABSORBER:

Eccosorb MF-PP represents a family of injection molded absorbers based on a thermoplastic matrix with high magnetic loss. As such, Eccosorb MF-PP is a cost-effective alternative for Eccosorb MF for medium to high volume applications. It will withstand temperatures up to 120°C.

FEATURES AND BENEFITS

- Thermoplastic polymer amenable to injection molded processes
- Injection molding is ideal for complex shapes and high volume applications – results in lower part cost
- Environmentally friendly, RoHS/Reach compliant

MARKETS

- Telecom infrastructure and wireless networks
- Automotive radar
- Satellite communications
- Military electronics
- Industrial instrumentation
- Medical

SPECIFICATIONS

TYPICAL PROPERTIES	ECCOSORB MF-PP
Tensile Strength (MPa)	10.5
Service Temperature °C (°F)	85 (185)
Density (g/cm³)	4.2
Hardness (Shore A)	80

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

APPLICATIONS

- Eccosorb MF-PP products are used as attenuator and termination in waveguides, coaxial or stripline application.
- Other applications include phase shifters in phased array antennas and structural absorbers for board-level and above board EMI suppression. Board-level solutions include high loss chip-cap structures which combine both shielding and absorption
- Above board, structural covers in Eccosorb MF-PP material are a cost-effective alternative for traditional solutions where an absorbing material is glued on the metallic cover.

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Europe: +49.8031.24600

Asia: +86.755.2714.1166

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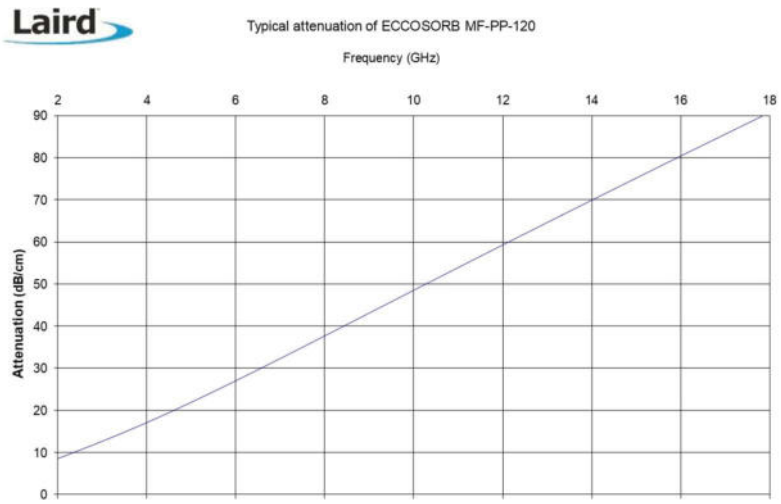
ECCOSORB®MF-PP

Magnetically Loaded Thermoplastic Absorber

AVAILABILITY

- Eccosorb MF-PP is the standard available grade.
- Other grades are available upon request.
- Products are custom designed in consultation with the customer.

Our application engineers will assist the customer in the complete process, from design to final product. The customized solutions mostly come with a smart mechanical fixing so that no glue is required.



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RFP-DS-MF-PP 081215

ECCOSORB®MF-PA

High Temperature, Magnetically Loaded Thermoplastic Absorber

INJECTION MOLDABLE THERMOPLASTIC ABSORBER:

Eccosorb MF-PA represents a family of injection molded absorbers based on a thermoplastic matrix with high magnetic loss. Eccosorb MF-PA is a high temperature alternative for Eccosorb MF-PP for medium to high volume applications.

FEATURES AND BENEFITS

- Thermoplastic polymer amenable to injection molded processes
- Injection molding is ideal for complex shapes and high volume applications – results in lower part cost
- Environmentally friendly, RoHS/Reach compliant
- Halogen free
- High Temperature Resistance
- Low outgassing – < 1.00% TML and <0.10% CVCM

MARKETS

- Telecom infrastructure and wireless networks
- Automotive radar
- Satellite communications
- Military electronics
- Industrial instrumentation
- Medical

SPECIFICATIONS

TYPICAL PROPERTIES	ECCOSORB MF-PA
Tensile Strength (MPa)	47
Max. Service Temperature °C (°F)	170 (338)
Density (g/cm³)	4.27
Durometer Hardness (Shore D)	87

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

APPLICATIONS

- Eccosorb MF-PA products are used as attenuator and termination in waveguides, coaxial or stripline application.
- Other applications include phase shifters in phased array antennas and structural absorbers for board-level and above board EMI suppression. Board-level solutions include high loss chip-cap structures which combine both shielding and absorption. Above board, structural covers in Eccosorb MF-PA material are a cost-effective alternative for traditional solutions where an absorbing material is glued on the metallic cover.

AVAILABILITY

- Eccosorb MF-PA is the standard available grade.
- Products are custom designed in consultation with the customer.

Our application engineers will assist the customer in the complete process, from design to final product. The customized solutions mostly come with a smart mechanical fixing so that no glue is required.

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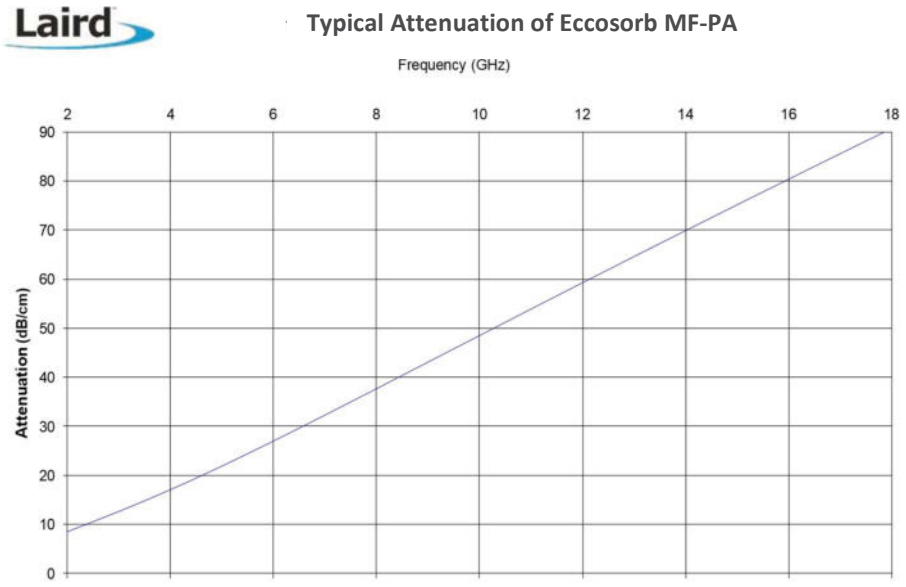
ECCOSORB®MF-PA

High Temperature, Magnetically Loaded Thermoplastic Absorber



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RFP-DS-MF-PA 102615

ECCOSORB® MF-PPS

Thermoplastic, Injection Moldable Absorber

HIGH TEMPERATURE, MAGNETICALLY LOADED ABSORBER

Rigid, magnetically loaded, injection moldable load absorber. Typically used as attenuators and terminations in microwave transmission lines such as for waveguide, coaxial or stripline applications. Other applications include phase shifters in phased array antennas and board level absorber covers that result in EMI reduction through combination of absorption and shielding.

FEATURES AND BENEFITS

- Thermoplastic polymer amenable to injection molding processes
- Injection molding is ideal for complex shapes and high volume applications - results in lower part cost
- High service temperature of polymer is amenable to solder reflow processes
- Environmentally friendly and meets RoHs and REACH requirement
- Passes UL94 V0 testing
- Low outgassing - < 1.00% TML and <0.10% CVCM

MARKETS

- Telecom infrastructure and wireless networks
- Satellite communications
- Automotive radar
- Military electronics
- Industrial instrumentation
- Medical

TYPICAL PROPERTIES	ECCOSORB MF-PPS
Density (g/cc)	4.48-4.66
Tensile Strength (psi)	8,000
Hardness (Shore D)	92
Max Service Temperature (°C)	210
Surface Resistivity (Ohm/Square)	10^{11}
Water Absorption (%)	<0.01%
Thermal Conductivity (W/m-K)	1.2
Dielectric Breakdown (Volt/mil)	6.2

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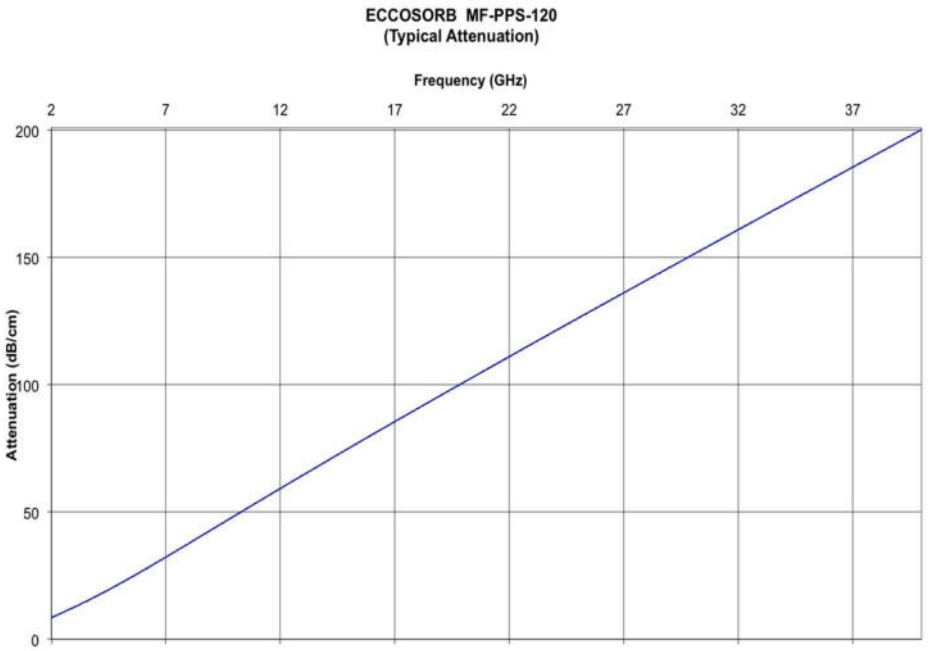
ECCOSORB® MF-PPS

Thermoplastic, Injection Moldable Absorber

MATERIAL CHARACTERISTICS AND RELATED PRODUCTS

Rigid, magnetically loaded absorbers have cost advantage in high volume applications or for complex shapes that would otherwise be cost prohibitive as machined parts. Thermoplastic injection molded absorbers generally have low shrinkage (<0.3%). When part is complex in shape, lower MOQs can be economical to produce. DXF-drawing files are needed for optimization of mold design.

Eccosorb MF-PPS has equivalent magnetic and dielectric properties to comparably loaded thermoset absorbers in the Eccosorb MF, MF500F and BSR/MFS product lines. See graph below for attenuation properties of MF-PPS as a function of frequency.



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RFP-DS-MF-PPS 112315

ECCOSORB®MF-TPE

Magnetically Loaded Flexible Thermoplastic Absorber

FLEXIBLE INJECTION MOLDABLE THERMOPLASTIC ABSORBER

Eccosorb MF-TPE represents a family of injection molded absorbers based on a flexible thermoplastic matrix with high magnetic loss. As such, Eccosorb MF-TPE is an alternative to Eccosorb MF-PP when flexibility is required. Both products are the ideal choice for medium to high volume applications.

FEATURES AND BENEFITS

- Thermoplastic polymer amenable to injection molded processes
- Injection molding is ideal for complex shapes and high volume applications – results in lower part cost
- Environmentally friendly, RoHS/Reach compliant

MARKETS

- Telecom infrastructure and wireless networks
- Automotive radar
- Satellite communications
- Military electronics
- Industrial instrumentation
- Medical

SPECIFICATIONS

TYPICAL PROPERTIES	ECCOSORB MF-TPE
Tensile Strength (MPa)	6
Service Temperature °C (°F)	85 (185)
Density (g/cm³)	4.1
Hardness (Shore A)	60
Elongation %	1800

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

APPLICATIONS

- Eccosorb MF-TPE products can be used as attenuator and termination in waveguides, coaxial or stripline application.
- Other applications include phase shifters in phased array antennas and structural covers to suppress interferences

AVAILABILITY

- Eccosorb MF-TPE is the standard available grade. Other grades with intermediate losses are available upon request.

Our application engineers will assist the customer in the complete process, from design to final product. The customized solutions mostly come with a smart mechanical fixing so that no glue is required.

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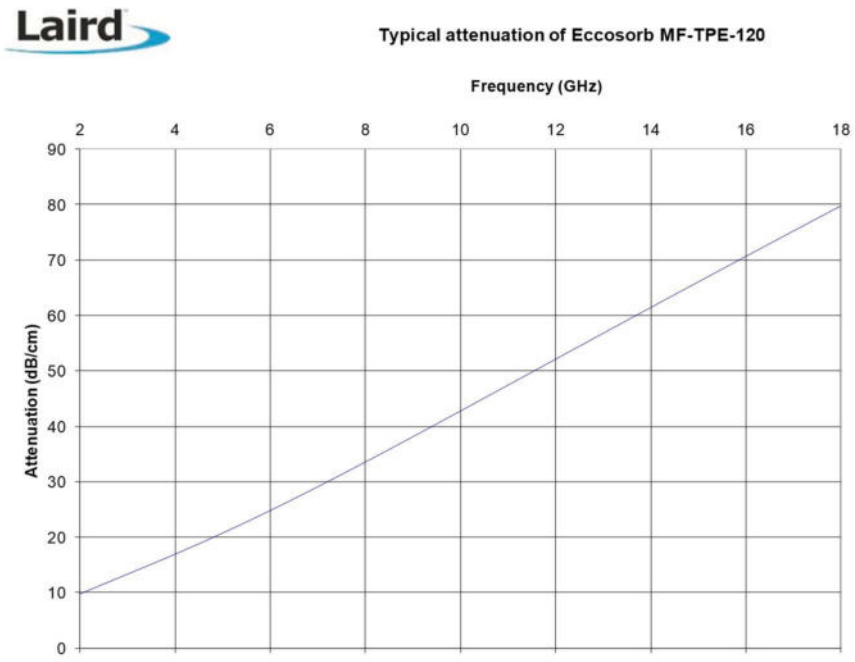
ECCOSORB®MF-TPE

Magnetically Loaded Flexible Thermoplastic Absorber



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RFP-DS-MF-TPE 093015

Eccosorb®

JCP-PBT-252
(Preliminary)

ABSORBER

Eccosorb JCP-PBT-252 is an injection molded absorber grade based on a PBT thermoplastic matrix.

Reinforced with glass fiber, this absorber grade is exhibiting good stability and enhanced mechanical properties.

This compound is loaded with specific filler and can be used in high volume applications that require reduction of interference and enhanced performances trough absorbers material.

FEATURES AND BENEFITS

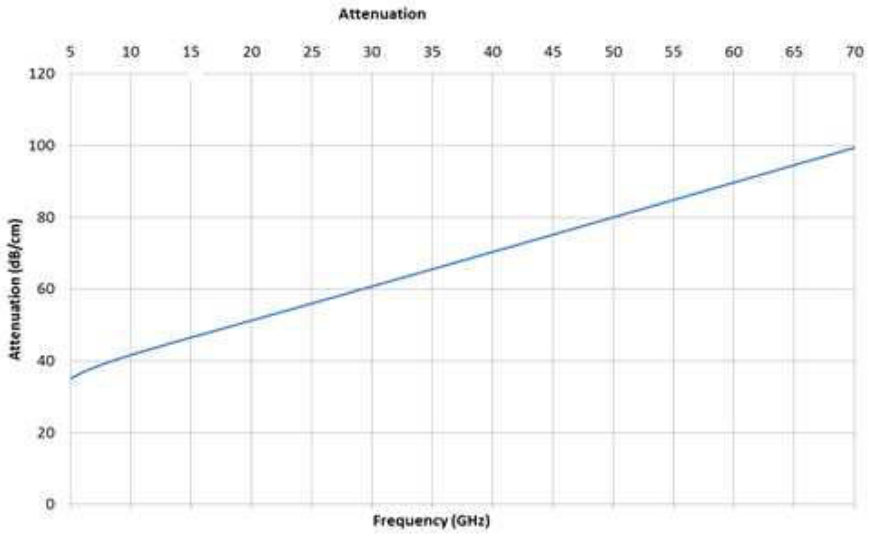
- Thermoplastic polymer amenable to injection molding processes
- Injection molding is ideal for complex shapes and high volume applications – results in lower part cost
- Suitable for intermediate structural parts

MARKETS

- Automotive radar
- Medical
- Industrial instrumentation/equipment
- Military electronics

SPECIFICATIONS

TYPICAL PROPERTIES	ECCOSORB JCP-PBT-252
Matrix	PBT
Color	Black/grey
Density (g/cm³)	1.55
Service temperature(°C)	130



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

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APPLICATIONS

- Typical applications in automotive radar radome and bracket to enhance radar performance and reliability
- Interference mitigation
- Parts made of Eccosorb JCP-PBT-252 are a cost-effective alternative for traditional solutions where an absorbing material is glued onto a substrate.

AVAILABILITY

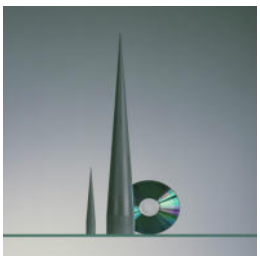
- JCP-PBT-252 is a standard available grade and will be supplied according to a specific drawing and request of the customer. Laird Technologies will supply additional engineering services for finding the best compromise in both mechanical fixation and RF performance.

INSTRUCTIONS FOR USE

•Our application engineers will assist the customer in the complete process, from prototype design to finished series product.

Eccosorb®MF500F

High Temperature, Magnetically Loaded, Machinable Stock



HIGH TEMPERATURE MAGNETICALLY LOADED MACHINABLE STOCK

Eccosorb MF500F is a rigid, completely solid, magnetically loaded, high temperature absorber. Physical and electrical properties are the same as those of the corresponding member of the Eccosorb MF series. Eccosorb MF500F can be used for short periods at 260°C(500°F) permitting use at high ambient and/or high power levels.

FEATURES AND BENEFITS

- Rigid and machinable
- High Temperature

MARKETS

- Commercial Telecom
- Security and Defense

SPECIFICATIONS

TYPICAL PROPERTIES	ECCOSORB MF500F
Frequency Range	>1 GHz
Short Time Service Temperature °C (°F)	<260 (<500)
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 MF500F 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.

AVAILABILITY

- Eccosorb MF500F is available in six standard loadings. In general, as the frequency of operation increases, the MF500 loading series decreases.

MF500F-110	MF500F-114	MF500F-117
MF500F-112	MF500F-116	MF500F-124

- Eccosorb MF500F 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.

INSTRUCTIONS FOR USE

- Exposure to high temperatures should be limited. Slow changes in physical and electrical properties occur at temperatures above about 177°C (350°F).

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MACHINING RECOMMENDATIONS

Most of the discussion below applies not only to the basic Eccosorb MF500F series of materials, but also to several high temperatures, castable and molding-powder equivalents. Eccosorb MF500F 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

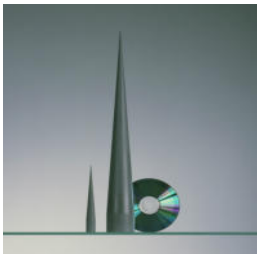
The following speeds and feed rates are suggested to be modified as necessary to suit job conditions:

OPERATION	SPEED	FEED
Sawing, turning	21.3 - 27.4 m/min (70-90 ft/min)	0.13 - 0.20 mm/revolution (.005-.008 in/revolution)
External threading	21.3 - 27.4 m/min (70-90 ft/min)	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)

- For complete properties and design considerations, see the Eccosorb MF technical bulletin.

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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Europe: +49.(0)8031.2460.0
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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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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 δ_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
$\lvert Z\rvert/Z_0$	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