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# MICROWAVE ABSORBING MATERIALS

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# CAPABILITIES

Microwave absorbers are increasingly being used to enhance shielding performance at higher frequencies. R&F Products, a division of Laird Technologies®, offers a wide product range for the EMC design engineer. Products including die-cut elastomers, foam, thermoplastics and custom solutions can aid in a wide variety of problems such as internal cavity resonances, antenna pattern shaping and high-frequency interference.

Whatever the problem, R&F Products can design a solution.




**Free-Space Arch**

The free-space arch is used to characterize the reflectivity reduction of a microwave absorber over the 2-18GHz range.



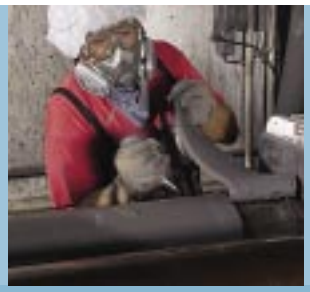
**Timesavers Machine**

Precision grinding allows for accurate thickness control of elastomeric absorbers, honeycomb and structural foams.



**Spray Booth**

Automated spraying of resistive coatings allows for reproducible graded dielectric absorbers.



**Mixer**

The two-roll mill allows for mixing any customer specified elastomer with magnetic and dielectric fillers.



**Extruder**

Magnetically loaded thermoplastic tape absorbers can be made on continuous rolls via the extrusion process.



**CNC Mill**

A multi-axis CNC mill allows for machining of complex shapes for structural absorbers.



**Tensile Tester**

The mechanical properties of absorbers are determined for batch-to-batch consistency.

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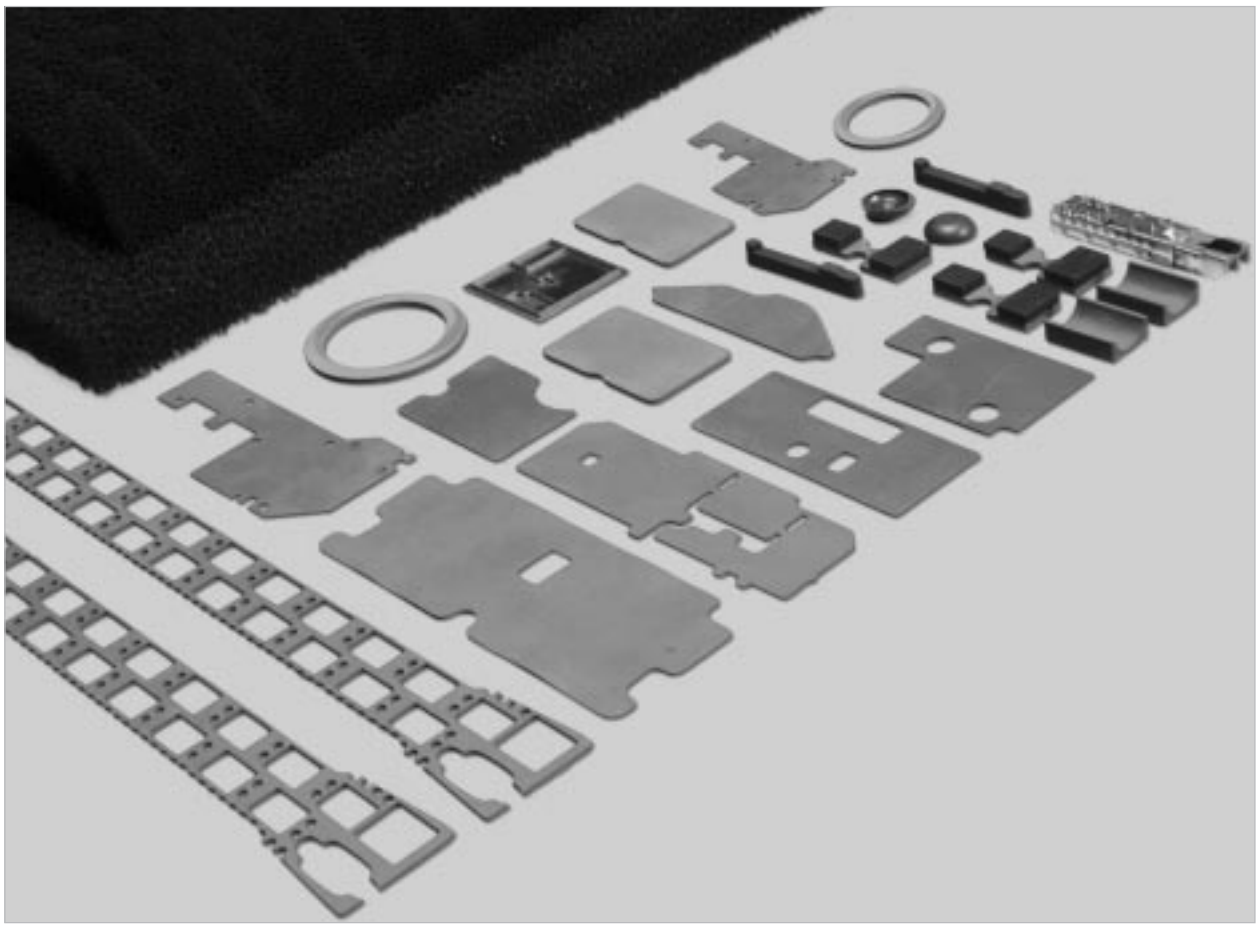
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Nomex®, Hypalon®, Viton® and Kevlar® are registered trademarks of DuPont.
Windows® is a registered trademark of Microsoft.


All dimensions shown are in inches (millimeters) unless otherwise specified.

# PART NUMBER CROSS REFERENCE

When ordering, please call our sales department to confirm availability and lead times.


| Part No. | Product | Page No. |
|---|---|---|
| **1000-2999** | **Q-Zorb® MICROWAVE ABSORBING ELASTOMERS** | |
| 1000-1999 | Q-ZORB SINGLE BAND ABSORBERS | 8 |
| 2000-2999 | Q-ZORB SURFACE WAVE ABSORBERS | 10 |
| **4000-4999** | **RETICULATED FOAM MICROWAVE ABSORBERS** | |
| 4000-4299 | GRADED RETICULATED FOAM ABSORBERS | 12 |
| 4300-4399 | UNIFORM RETICULATED FOAM ABSORBERS | 12 |
| 4500-4599 | CONVOLUTED RETICULATED FOAM ABSORBERS | 12 |
| 4700-4799 | RIGID RETICULATED FOAM ABSORBERS | 15 |
| **5000-5999** | **OPEN-CELL FOAM ABSORBERS** | |
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There has been a growing and widespread interest in microwave-absorbing material technology. As the name implies, microwave-absorbing materials are coatings whose electrical and/or magnetic properties have been altered to allow absorption of microwave energy at discrete or broadband frequencies. There are several techniques to achieve these properties. The goal of the absorber manufacturer is to balance electrical performance, thickness, weight, mechanical properties and cost.

## PRINCIPLES OF OPERATION

Altering the dielectric and magnetic properties of existing materials will produce microwave absorbers. For purposes of analysis, the dielectric properties of a material are categorized as its permittivity and the magnetic properties as its permeability. Both are complex numbers with real and imaginary parts. Common dielectric materials used for absorbers, such as foams, plastics and elastomers, have no magnetic properties, giving them permeability of 1. Magnetic materials, such as ferrites, iron and cobalt-nickel alloys, are used to alter the permeability of the base materials. High dielectric materials, such as carbon, graphite and metal flakes, are used to modify the dielectric properties.

When an electromagnetic wave, propagating through a free-space impedance of $Z_0$, is incident upon a semi-infinite dielectric or magnetic dielectric boundary of impedance $Z_1$, a partial reflection occurs. The magnitude of the reflection coefficient is governed by the following equation:

$$R = \frac{1 - Z_1/Z_0}{1 + Z_1/Z_0} \qquad [1]$$

Where

$$Z_0 = \sqrt{\frac{u_0}{e_0}} \qquad [2]$$

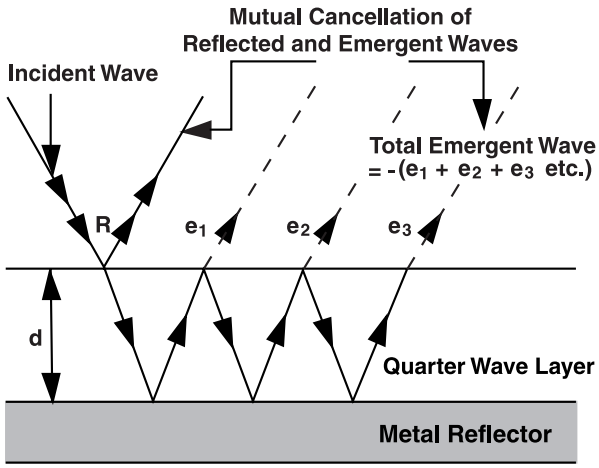
$$Z_1 = \sqrt{\frac{u_1}{e_1}}$$

To achieve a reflection coefficient of zero: $Z_0 = Z_1$. This condition is achieved when:

$$\frac{u_1}{e_1} = \frac{u_0}{e_0} \qquad [3]$$

The perfect absorber would therefore have $u_1$ to $e_1$ and be as large as possible to achieve absorption in the thinnest layer possible. Unfortunately, at microwave frequencies, $u_1$ generally does not approach the magnitude of $e_1$. However, other techniques can be used for microwave absorption. In general, practical microwave absorbers are one of two basic types: resonant or graded dielectric.

FIGURE 1.

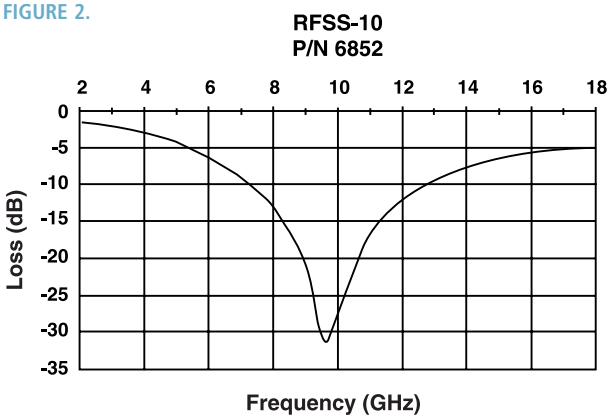



Resonant absorber showing out-of-phase condition existing between reflected and emergent waves.

## RESONANT ABSORBERS

The simplest type of resonant absorber is the Salisbury Screen. It consists of a resistive sheet spaced one-quarter wavelength from a conductive ground plane. The resistive sheet is as thin as possible with a resistance of 377 ohms per square matching that of free space. Figure 1 illustrates its operation. A wave incident upon the surface of the screen is partially reflected and partially transmitted. The transmitted portion undergoes multiple internal reflections to give rise to a series of emergent waves. At the design frequency, the sum of the emergent waves is equal in amplitude to, by 180° out of phase with, the initial reflected portion. In theory, zero reflection takes place at the frequency; in practice, absorption of greater than 30dB (99.9%) may be achieved (see Figure 2).

FIGURE 2.




Salisbury Screen resonant absorber at 10GHz.

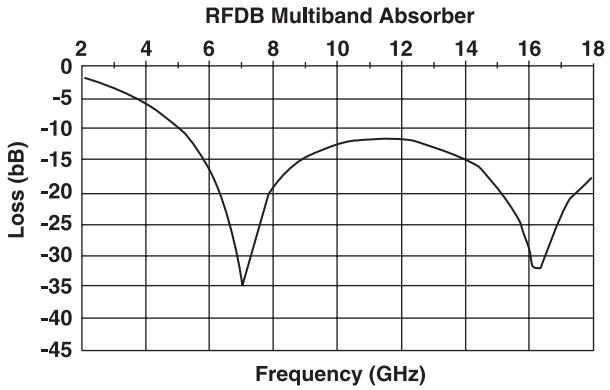
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The inherent problems of the Salisbury Screen are poor flexibility, poor environmental resistance and increased thickness, especially at lower frequencies. Distributing dielectric and/or magnetic fillers into a flexible matrix, such as an elastomer, can produce a more practical absorber. Increasing the permeability and permittivity of the layer increases the refractive index $\sqrt{ue}$, thus decreasing thickness by the relations $1/\sqrt{ue}$. The dramatic difference in thickness achievable can be illustrated by comparing two microwave absorbers. RFSS-10 is a Salisbury Screen-type absorber tuned to 10GHz and is nominally 0.250" (6.4 mm) thick. RFSB-10 is an elastomer loaded with carbonyl iron filler and is 0.068" (1.7 mm) thick. The same electrical performance can be achieved in a material that is 25% as thick (although a weight penalty must be paid). The RFSB absorber is also very flexible and adaptable to outdoor environments.

Resonant materials can also be produced to absorb at multiple frequencies. By controlling the critical magnetic/dielectric loading and thickness of each layer, two discrete frequencies can be tuned. These flexible dual-band absorbers are standard production products and have the added advantage of broadband absorption. For example, a dual-band absorber with appropriate resonant points will have greater than 15dB absorption over an octave bandwidth (see Figure 3).

FIGURE 3.




Dual-magnetic absorber – nitrile rubber 0.200" (5.1 mm) thick, 1.75 lb. sq.ft.

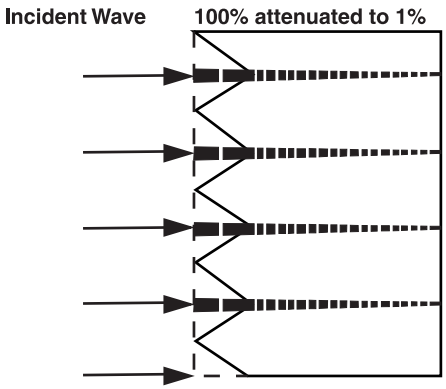
The performance indicated for resonant absorbers is at normal angles of incidence. The effectiveness of these materials drops off as the angle of incidence increases. Materials have been developed for situations where performance is needed at angles of incidence of 65° and greater. These absorbers are generally thin and heavily loaded with magnetic fillers. Such high-permeability absorbers have a greater than critical impedance at normal angles of incidence, thus resulting in performance that is poorer than the resonant type at normal angles but improves as angle of incidence increases. They are generally tuned for a high angle of incidence and horizontal polarization.

## GRADED-DIELECTRIC ABSORBERS

The other absorber category is the graded-dielectric absorber. Its principle of operation is quite different from that of the resonant type. Absorption is achieved by a gradual tapering of impedance from that of free space to a highly "lossy" state. If this transition is done smoothly, little reflection from the front face will result. Anechoic chamber materials accomplish this via the pyramidal shape of the absorber (see Figure 4). The absorbing medium is a conductive carbon in polyurethane foam. Absorption levels of greater than 50dB can be obtained with pyramids many wavelengths thick. These are impractical for electromagnetic interference (EMI) or radar cross-section (RCS) reduction. Good levels of reflectivity reduction (greater than 20dB) can be achieved in materials less than 1/3 wavelength thick. In this case, a very open-celled (10 pores per inch) foam is used. A gradual transition is achieved via a conductive carbon coating. Figure 5 depicts typical performance where reflectivity levels of –20dB are achieved from 4 to 18GHz and above at a thickness of 1.25" (31.8 mm).

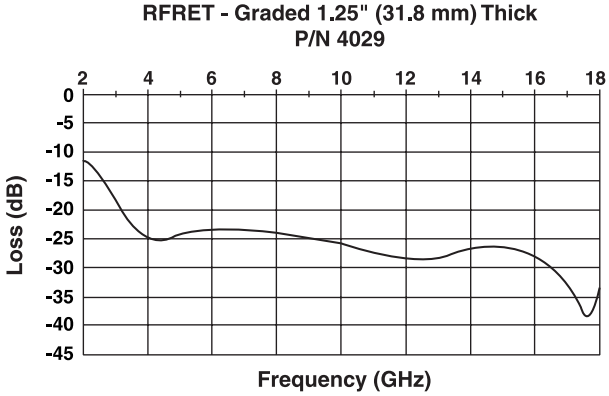
This method of gradual impedance transition can be applied to other materials. Foams, honeycombs and netting are three such matrices where practical absorbers are being produced.

FIGURE 4.




Broadband absorber with tapered impedance. The low loss front face can be obtained by physical tapering or control of dielectric properties.

FIGURE 5.




Broadband-graded reticulated foam absorber 1.25" (31.8 mm) thick.

All dimensions shown are in inches (millimeters) unless otherwise specified.

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## MATERIAL SELECTION

A wide variety of absorber materials are available for use in EMI and RCS reduction. There are tradeoffs involved in the use of each candidate material. To optimize the use of absorbers in a design, there are three sets of parameters that should be critically analyzed: electrical, physical and application.

Although the "DC to daylight" goal has not been achieved, considerable strides have been made to broaden frequency coverage across the microwave region. In optimizing absorber use, the requirement must be defined as completely as possible. The following questions should be asked:

1. What frequency bands need coverage?
2. Is coverage needed over the entire region or just at specific frequencies? For example, if coverage cannot be achieved over the entire 2 to 18GHz region, will absorption at specific frequencies provide enough protection?
3. What is the order of importance in coverage? Perhaps at $F_0$, 20dB absorption is needed. However, at $F_1$, only 12dB is needed; at $F_2$, 7dB is acceptable. By setting these priorities, a design can be more easily reached.
4. Will the absorber be used to absorb specular energy, or is the application such that high angles of incidence radiation and surface waves must be attenuated?

By answering these questions, the various tradeoffs in electrical performance can be examined and an optimum absorber solution derived.

## ELECTRICAL PERFORMANCE GUIDELINES

1. The broader the frequency coverage, the thicker, heavier and more expensive the absorber.
2. The lower the minimum frequency coverage, the thicker and heavier the absorber.
3. Normal incidence performance is better than off-normal performance for most types of absorbers, although they can be designed for off-normal performance.
4. Millimeter-wave materials are now being developed and used.

Of equal importance to the material's electrical performance is its physical performance, which includes environmental characteristics, temperature characteristics and mechanical properties. Again, a series of questions can help clarify the parameters of major importance:

1. What is the application environment? Will the absorber be enclosed or subjected to the outdoor environment?
2. What environmental forces will be degrading the absorber? Some examples are salt, water, ozone, oxygen, ultraviolet light, fuels, oils, chemicals, nuclear and stack gases.
3. Over what temperature range will the material be subjected, and within what thermal range must the material perform?
4. What mechanical stresses will be placed on the absorber? Examples are vibration, thermal shock, elongation or wind.
5. What is the expected lifetime of the absorber? For example, missile applications may not require the same degree of physical integrity as a shipboard application.

All dimensions shown are in inches (millimeters) unless otherwise specified.

## PHYSICAL PERFORMANCE GUIDELINES

1. The elastomeric-type (rubber) absorbers have better environmental resistance than the broadband foam types. These types have been used successfully on surface ships for more than 40 years.
2. A variety of elastomers are available to aid in designing for a specific environment. Hypalon® is widely used in naval applications because of superior weather resistance and color fastness. Nitrile is used for fuel and oil resistance. Fluoro-elastomers and silicones have an excellent operating temperature range.
3. Broadband absorption is obtainable with the dual-layer elastomeric absorbers.
4. Broadband foam materials can be used for external environments, but steps must be taken to protect the absorber. Open-cell foams can be filled with low-loss plastics to make rigid panels for use outdoors. Broadband absorbers can be encapsulated in fiber-reinforced plastics to form flexible absorber panels that can be draped over reflectors.
5. The useful temperature range of most absorber material is –65°F to 250°F. Certain materials are available with higher maximum temperatures.

## ABSORBER TYPES

### Elastomeric Absorbers

These thin, flexible absorbers are best for outdoor use. The method of application is adhesive bonding to a metal substrate. Adhesives vary with the type of elastomer chosen and include: epoxies, urethanes, contact adhesives and pressure-sensitive adhesives (PSA). In general, Hypalon and nitrile are the easiest elastomers to bond and have a variety of compatible adhesive systems available. Bond strengths in excess of 10 pounds per inch are typical. In some cases, it is necessary to cover a tight radius or complex curvature. An alternative to flat sheet material is conformally molded parts. Conformal molds increase the ease of bonding and reduce the likelihood of applying any built-in stresses into the material. For gasket applications, the elastomeric absorber may be extruded.

To improve weather resistance, the absorber is painted. Typically, an epoxy- or urethane-based paint is used. To avoid gaps between sheets, absorptive gap fillers are used to minimize any impedance mismatches from sheet to sheet. This technique also limits the formation of surface waves and reflections. Newer non-corrosive fillers, such as iron silicide, are also available for corrosive environments.

### Broadband Absorbers

Open-cell foam absorbers are normally used in a protected environment, i.e. radomes or nacelles. Therefore, application becomes much less critical than for those on the exterior of a vehicle. The typical method of application is adhesive bonding. Again, a wide class of adhesives may be used, including contact cements, epoxies and acrylic PSA. In general, cohesive failure of the material will result before adhesive failure. The front surfaces may be painted or coated to further protect the absorber.

R&F uses two methods to produce broadband absorbers for external use. The first method involves taking broadband foam or netting absorber and encapsulating it in a reinforced coated fabric. The bagging material is completely enclosed around the absorber making it weather proof. This radar-absorptive cover can then be used in external environments with no physical degradation to the absorbing medium.

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A second method uses a closed-cell foam filling technique to produce rigid structural absorptive panels. The absorber, RFRIGID, is lightweight and may be molded to a variety of shapes. It has broadband absorptive characteristics similar to the flexible foam RFRET absorbers. The rigid, closed-cell form may be painted and will be impervious to external environments. A variety of high-strength, lightweight, flexible fillers for RFRIGID are being developed.

RFRIGID and absorptive honeycomb may be used as the inner core for structural panels. The panel would consist of face sheets of fiberglass or Kevlar® facing the radar and graphite or metal as the ground plane. These panels are lightweight and high strength and can be used as structure in certain applications.

## APPLICATIONS

The two largest applications for radar-absorbing materials are for EMI and for RCS reduction in military and commercial electronics.

### Military

Today's modern warship has a wide variety of electronic systems on board. Navigational and target-acquisition radar, countermeasure systems and a wide variety of communication equipment are all mounted on a large metal superstructure. This arrangement creates two major problems: false images from self-reflections and system-to-system interference.

False images or "ghosts" are indirect radar returns resulting from specular reflections of radar energy off the ship's own superstructures. False echoes cause navigation hazards and, if severe enough, can make radar navigation impossible. False returns to target acquisition and fire control systems can cause the system to "lock on" to the false images. These problems can be eliminated through the use of tuned-frequency elastomeric absorbers. Tuned to the frequency of the radar, the absorber is bonded to masts, stacks, yardarms and other reflecting structures. By properly situating the material, false echoes can be reduced by 40dB.

The lack of space available on modern warships causes electronic systems to be placed in close proximity. Often a signal or harmonics from one system will be received by or interfere with an adjacent system. This problem has become especially acute with the powerful broadband jamming equipment currently being deployed, but constructing absorber barriers can alleviate it. Depending on the systems involved, single-frequency, dual-frequency or broadband absorbers will be used.

Antenna pattern improvement is an area of universal application for microwave absorbers. Conductive objects in the near field of an antenna can greatly alter its free-space propagation characteristics. The net effect of this is a wider main beam with increased side lobes. This condition can reduce system discrimination and increase the possibility of side lobe jamming. The application of absorbing material to the conductive areas will effectively match out radiation propagated in these directions and return the system to its designed free-space characteristics. A variety of antennas use absorber material for this problem, and to coat feeds, struts and mounts, which act as reflectors.

### Commercial

There is a growing use of absorbers for reduction of interference in commercial electronics. High-frequency wireless devices often have powerful transmitters and sensitive receivers in close proximity inside a cavity or housing. Spurious signals can cause leakage or system interference, which degrades performance. Magnetic absorbers inside the cavity can reduce the "Q" of the cavity and absorb unwanted reflections. Applications for absorbers can be found in wireless LAN devices, network servers, VSAT transceivers, radios and other high-frequency devices. Custom shapes are die-cut from sheet material with pressure-sensitive adhesive for application inside the noisy cavity.

As devices such as computers and cell phones move to higher frequencies and speeds, the need for absorbers or absorbing shields will increase.

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# Q-ZORB® RFSB – SINGLE BAND ABSORBERS

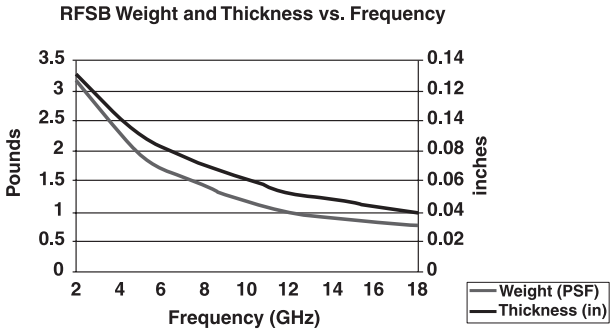
Q-Zorb RFSB absorbers are resonantly tuned to discrete frequencies between 500MHz and 100GHz. They are designed to reduce energy reflections off of a conductive ground plane by > 99% (-20dB) at normal angles of incidence. The performance is based upon the principle of phase cancellation by the incident energy reflection being out of phase with the ground plane reflection. For further discussion on resonant absorbers see "Introduction to Microwave Absorbers" on page 3.

The materials are thin, flexible and easy to cut and install. They are elastomer- based with a variety of choices available. For example, silicone is chosen for high-temperature applications, nitrile for fuel and oil resistance and natural rubber for commercial applications. Several magnetic fillers are available; carbonyl iron powder is standard, but other materials such as iron silicide (FeSi) are used for corrosion-resistant applications. The density of the materials is based on the volume percentage of magnetic filler. Table 1 gives the relationship between resonant frequency, weight and thickness.



RFSB absorbers require a conductive backing to achieve the reflectivity results shown. For applications where a conductive backing is not available, R&F can supply a ground plane bonded to the sheet. Pressure-sensitive adhesives can also be provided for ease of installation.

## TABLE 1: RFSB WEIGHT AND THICKNESS VS. FREQUENCY




## APPLICATIONS

Single band absorbers are used for maximum normal incidence attenuation at a discrete frequency. They are commonly used to minimize antenna reflections off of a structure or for antenna pattern shaping. They are also used for discrete frequency test chambers for devices such as transceivers, wireless devices and antenna test hoods. They are typically molded in flat sheets, but can be molded into conformal shapes or extruded into tape, gaskets and tubing.

FIGURE 1.

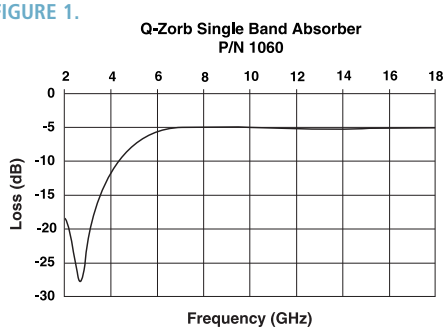



FIGURE 2.

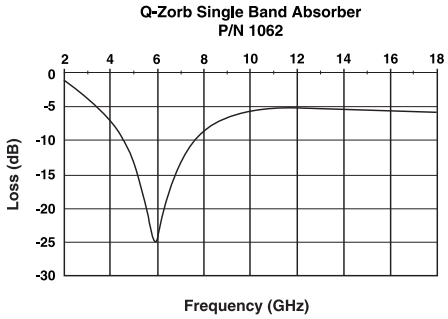



FIGURE 3.

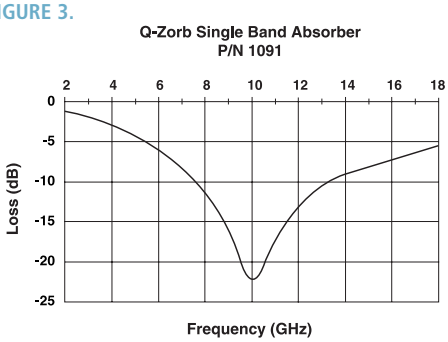
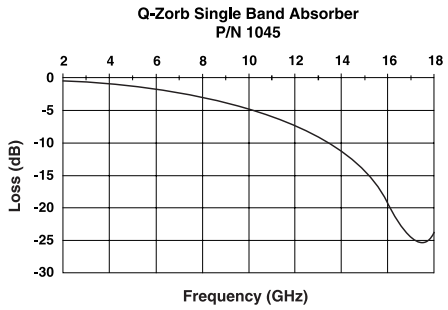



FIGURE 4.




All dimensions shown are in inches (millimeters) unless otherwise specified.

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## ORDERING INFORMATION

Select the desired frequency of operation (listed in ascending order) from Table 2. This selection will govern dB loss and thickness. Then choose the material type and other options including flame retardant (FR), pressure-sensitive adhesive (PSA), ground plane (GP), or iron silicide (FeSi) and select a part number.

**Material Types Available:**

S – Silicone
N – Nitrile
R – Natural Rubber
U – Urethane
V – Viton®
W – Neoprene
H – Hypalon®

## TABLE 2: RFSB – SINGLE BAND ABSORBER PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

### 1000 – 1999 RFSB – SINGLE BAND ABSORBERS

| NUMBER | MATERIAL TYPE | FREQ (GHZ) | DB LOSS | THICKNESS IN (MM) | OTHER |
|---|---|---|---|---|---|
| 1020 | R | 0.445 | -15.0 | 0.500 (12.7) | |
| 1121 | R | 0.500 | -15.0 | 0.500 (12.7) | |
| 1036 | R | 0.900 | -15.0 | 0.280 (7.1) | |
| 1122 | R | 1.000 | -15.0 | 0.250 (6.4) | |
| 1019 | N | 1.400 | -15.0 | 0.165 (4.2) | |
| 1065 | R | 1.500 | -15.0 | 0.150 (3.8) | PSA |
| 1048 | R | 1.500 | -15.0 | 0.150 (3.8) | |
| 1039 | N | 1.575 | -20.0 | 0.148 (3.8) | PSA |
| 1049 | R | 1.880 | -20.0 | 0.140 (3.6) | PSA |
| 1031 | N | 1.960 | -17.0 | 0.132 (3.4) | PSA |
| 1011 | N | 1.960 | -17.0 | 0.132 (3.4) | GP-PSA |
| 1007 | N | 1.960 | -17.0 | 0.132 (3.4) | |
| 1027 | S | 2.100 | -20.0 | 0.105 (2.7) | |
| 1125 | N | 2.250 | -20.0 | 0.115 (2.9) | PSA |
| 1124 | N | 2.250 | -20.0 | 0.115 (2.9) | |
| 1060 | R | 2.400 | -20.0 | 0.100 (2.5) | PSA |
| 1059 | R | 2.400 | -20.0 | 0.100 (2.5) | |
| 1084 | N | 3.000 | -20.0 | 0.115 (2.9) | GP |
| 1083 | N | 3.000 | -20.0 | 0.115 (2.9) | |
| 1044 | N | 3.200 | -20.0 | 0.105 (2.7) | PSA |
| 1043 | N | 3.200 | -20.0 | 0.105 (2.7) | |
| 1042 | S | 3.500 | -20.0 | 0.095 (2.4) | PSA |
| 1040 | S | 3.500 | -20.0 | 0.095 (2.4) | |
| 1134 | N | 3.900 | -20.0 | 0.115 (2.9) | FESI |
| 1101 | S | 4.000 | -20.0 | 0.095 (2.4) | |
| 1086 | N | 4.000 | -20.0 | 0.110 (2.8) | GP |
| 1085 | N | 4.000 | -20.0 | 0.110 (2.8) | |
| 1071 | R | 4.500 | -20.0 | 0.095 (2.4) | PSA |
| 1070 | R | 4.500 | -20.0 | 0.095 (2.4) | |
| 1104 | S | 5.000 | -20.0 | 0.095 (2.4) | |
| 1126 | N | 5.200 | -20.0 | 0.095 (2.4) | PSA |
| 1073 | N | 5.200 | -20.0 | 0.095 (2.4) | |
| 1123 | U | 5.500 | -18.0 | 0.075 (1.9) | |
| 1016 | R | 5.600 | -20.0 | 0.075 (1.9) | PSA |
| 1062 | S | 6.000 | -20.0 | 0.082 (2.1) | PSA |
| 1061 | S | 6.000 | -20.0 | 0.082 (2.1) | |
| 1088 | N | 6.000 | -20.0 | 0.085 (2.2) | GP |
| 1087 | N | 6.000 | -20.0 | 0.085 (2.2) | |
| 1008 | R | 6.175 | -20.0 | 0.080 (2.0) | PSA |
| 1105 | S | 6.500 | -20.0 | 0.075 (1.9) | |
| 1021 | R | 6.500 | -20.0 | 0.075 (1.9) | PSA |
| 1056 | N | 6.500 | -20.0 | 0.085 (2.2) | PSA |
| 1106 | S | 7.500 | -20.0 | 0.075 (1.9) | |
| 1033 | N | 7.500 | -20.0 | 0.075 (1.9) | PSA |
| 1032 | N | 7.500 | -20.0 | 0.075 (1.9) | |
| 1080 | S | 7.750 | -20.0 | 0.066 (1.7) | PSA |
| 1079 | S | 7.750 | -20.0 | 0.066 (1.7) | |
| 1107 | S | 8.000 | -20.0 | 0.070 (1.8) | |
| 1057 | N | 8.000 | -20.0 | 0.070 (1.8) | PSA |
| 1090 | N | 8.000 | -20.0 | 0.070 (1.8) | GP |
| 1089 | N | 8.000 | -20.0 | 0.070 (1.8) | |
| 1137 | N | 8.150 | -20.0 | 0.090 (2.3) | |
| 1130 | S | 8.400 | -20.0 | 0.070 (1.8) | |
| 1034 | N | 8.400 | -20.0 | 0.065 (1.7) | PSA |
| 1005 | N | 8.400 | -20.0 | 0.065 (1.7) | |
| 1035 | W | 9.100 | -20.0 | 0.075 (1.9) | |
| 1017 | N | 9.375 | -20.0 | 0.063 (1.6) | PSA |
| 1118 | N | 9.400 | -20.0 | 0.063 (1.6) | GP-PSA |
| 1013 | N | 9.400 | -20.0 | 0.063 (1.6) | |
| 1074 | H | 9.410 | -20.0 | 0.066 (1.7) | GP-PSA |
| 1068 | S | 9.500 | -20.0 | 0.060 (1.5) | |
| 1078 | N | 9.500 | -20.0 | 0.062 (1.6) | PSA |
| 1077 | N | 9.500 | -20.0 | 0.062 (1.6) | |
| 1025 | S | 9.700 | -20.0 | 0.060 (1.5) | |
| 1081 | U | 10.000 | -20.0 | 0.065 (1.7) | |
| 1092 | N | 10.000 | -20.0 | 0.060 (1.5) | GP |
| 1091 | N | 10.000 | -20.0 | 0.060 (1.5) | |
| 1075 | H | 10.000 | -20.0 | 0.062 (1.6) | PSA |
| 1018 | N | 10.100 | -20.0 | 0.060 (1.5) | PSA |
| 1024 | N | 10.200 | -20.0 | 0.065 (1.7) | |
| 1063 | N | 10.525 | -20.0 | 0.065 (1.7) | PSA |
| 1109 | S | 11.000 | -20.0 | 0.055 (1.4) | |
| 1009 | R | 11.200 | -20.0 | 0.056 (1.4) | PSA |
| 1029 | R | 11.200 | -20.0 | 0.056 (1.4) | GP-PSA |
| 1023 | R | 11.200 | -20.0 | 0.056 (1.4) | GP |
| 1115 | S | 12.000 | -20.0 | 0.052 (1.3) | |
| 1006 | R | 12.000 | -20.0 | 0.060 (1.5) | |
| 1110 | S | 13.000 | -20.0 | 0.050 (1.3) | |
| 1094 | N | 13.000 | -20.0 | 0.050 (1.3) | GP |
| 1093 | N | 13.000 | -20.0 | 0.050 (1.3) | |
| 1066 | V | 14.000 | -20.0 | 0.045 (1.1) | |
| 1067 | S | 14.000 | -20.0 | 0.045 (1.1) | |
| 1022 | N | 14.000 | -20.0 | 0.050 (1.3) | PSA |
| 1010 | R | 14.375 | -20.0 | 0.056 (1.4) | PSA |
| 1096 | N | 15.000 | -20.0 | 0.045 (1.1) | GP |
| 1097 | N | 15.000 | -20.0 | 0.045 (1.1) | |
| 1045 | N | 16.700 | -20.0 | 0.035 (0.9) | PSA |
| 1111 | S | 18.000 | -20.0 | 0.040 (1.0) | |
| 1014 | R | 18.200 | -15.0 | 0.040 (1.0) | PSA |
| 1038 | R | 18.200 | -15.0 | 0.040 (1.0) | |
| 1112 | S | 22.000 | -15.0 | 0.035 (0.9) | GP |
| 1116 | S | 22.400 | -15.0 | 0.035 (0.9) | |
| 1015 | R | 22.400 | -15.0 | 0.035 (0.9) | PSA |
| 1132 | N | 35.000 | -15.0 | 0.035 (0.9) | |

All dimensions shown are in inches (millimeters) unless otherwise specified.

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# Q-ZORB® RFSW – SURFACE WAVE ABSORBERS

Q-Zorb RFSW surface wave absorbers are thin, magnetically loaded elastomeric sheets designed to provide attenuation at high angles of incidence for surface wave attenuation. They are nominally manufactured in the thickness range of 0.015" to 0.125" (0.4 mm to 3.2 mm). They are elastomer-based with a variety of choices available. For example, silicone is chosen for high-temperature applications, nitrile for fuel and oil resistance and natural rubber for commercial applications. Several magnetic fillers are available; carbonyl iron powder is standard, but other materials such as iron silicide (FeSi) are used for corrosion- resistant applications. The materials are available in UL fire retardant versions for use in commercial devices. R&F can provide the material die-cut and with a pressure-sensitive adhesive for ease of installations. Sheets are offered in nominal sizes of 24" x 24" (609.6 mm x 609.6 mm), although custom sizes and molded components are available.



## APPLICATIONS

The material can be used inside of microwave housings to reduce internal resonance and to lower the "Q" of the microwave cavity. They are also effective in isolating antennas from ground plane reflections. Q-Zorb can be used with board level shielding and other types of EMI shielding to enhance the shielding effectiveness at frequencies from 2-40GHz.

FIGURE 1.

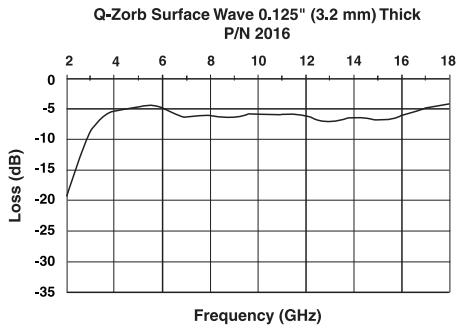



FIGURE 2.

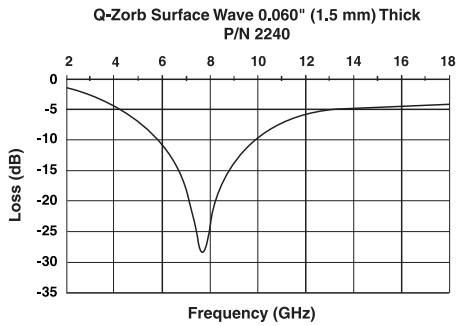



FIGURE 3.

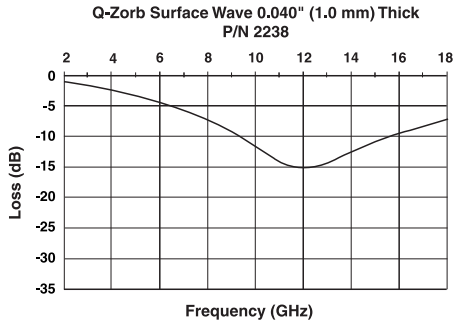
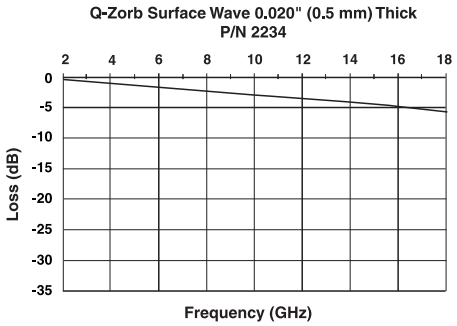



FIGURE 4.




## ORDERING INFORMATION

Select desired frequency of operation (listed in ascending order) from Table 1 on the next page. This selection will govern dB loss and thickness. Then choose material type and other options including flame retardant (FR), pressure- sensitive adhesive (PSA), ground plane (GP), or iron silicide (FeSi) and select a part number.

**Material Types Available:**

S – Silicone
N – Nitrile
R – Natural Rubber
U – Urethane
V – Viton®
W – Neoprene
H – Hypalon®

All dimensions shown are in inches (millimeters) unless otherwise specified.

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## TABLE 1: RFSW – SURFACE WAVE ABSORBER PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

### 2000 – 2999 RFSW – SURFACE WAVE ABSORBERS

| NUMBER | MATERIAL TYPE | THICKNESS IN (MM) | OPT. FREQ. RANGE (GHZ) * | OTHER |
|---|---|---|---|---|
| 2194 | S | 0.375 (9.5) | < 2 | |
| 2138 | S | 0.187 (4.7) | < 2 | |
| 2130 | N | 0.180 (4.6) | < 2 | |
| 2062 | R | 0.180 (4.6) | < 2 | PSA |
| 2178 | R | 0.180 (4.6) | < 2 | |
| 2049 | R | 0.175 (4.4) | < 2 | PSA |
| 2247 | R | 0.175 (4.4) | < 2 | |
| 2032 | R | 0.170 (4.3) | < 2 | |
| 2222 | S | 0.138 (3.5) | < 2 | |
| 2129 | N | 0.125 (3.2) | 2-4 | PSA |
| 2171 | N | 0.125 (3.2) | 2-4 | GP |
| 2170 | N | 0.125 (3.2) | 2-4 | |
| 2016 | R | 0.125 (3.2) | 2-4 | PSA |
| 2196 | R | 0.125 (3.2) | 2-4 | |
| 2142 | S | 0.125 (3.2) | 2-4 | PSA |
| 2242 | S | 0.125 (3.2) | 2-4 | FR-PSA |
| 2241 | S | 0.125 (3.2) | 2-4 | FR |
| 2264 | S | 0.125 (3.2) | 2-4 | |
| 2162 | N | 0.115 (2.9) | 2-4 | PSA |
| 2161 | N | 0.115 (2.9) | 2-4 | |
| 2041 | N | 0.110 (2.8) | 2-4 | PSA |
| 2044 | R | 0.110 (2.8) | 2-4 | PSA |
| 2258 | R | 0.110 (2.8) | 2-4 | |
| 2021 | N | 0.100 (2.5) | 2-4 | |
| 2220 | R | 0.100 (2.5) | 2-4 | PSA |
| 2094 | R | 0.100 (2.5) | 2-4 | |
| 2272 | S | 0.100 (2.5) | 2-4 | FR-PSA |
| 2271 | S | 0.100 (2.5) | 2-4 | FR |
| 2230 | S | 0.100 (2.5) | 2-4 | |
| 2167 | N | 0.095 (2.4) | 4-8 | |
| 2034 | R | 0.095 (2.4) | 4-8 | PSA |
| 2190 | S | 0.093 (2.4) | 4-8 | |
| 2068 | R | 0.090 (2.3) | 4-8 | PSA |
| 2087 | R | 0.090 (2.3) | 4-8 | |
| 2042 | N | 0.085 (2.2) | 4-8 | PSA |
| 2002 | N | 0.085 (2.2) | 4-8 | |
| 2123 | N | 0.080 (2.0) | 4-8 | PSA |
| 2122 | N | 0.080 (2.0) | 4-8 | |
| 2023 | R | 0.080 (2.0) | 4-8 | PSA |
| 2095 | S | 0.080 (2.0) | 4-8 | PSA |
| 2257 | S | 0.080 (2.0) | 4-8 | FR-PSA |
| 2256 | S | 0.080 (2.0) | 4-8 | FR |
| 2141 | S | 0.078 (2.0) | 4-8 | PSA |
| 2231 | S | 0.078 (2.0) | 4-8 | |
| 2248 | N | 0.075 (1.9) | 4-8 | |
| 2047 | R | 0.075 (1.9) | 4-8 | |
| 2225 | R | 0.072 (1.8) | 4-8 | |
| 2266 | N | 0.070 (1.8) | 4-8 | PSA |
| 2265 | N | 0.070 (1.8) | 4-8 | |
| 2080 | N | 0.065 (1.7) | 8-12 | PSA |
| 2082 | N | 0.065 (1.7) | 8-12 | GP-PSA |
| 2081 | N | 0.065 (1.7) | 8-12 | GP |
| 2097 | N | 0.065 (1.7) | 8-12 | |
| 2184 | U | 0.065 (1.7) | 8-12 | |
| 2185 | V | 0.065 (1.7) | 8-12 | |
| 2005 | R | 0.062 (1.6) | 8-12 | PSA |
| 2039 | N | 0.060 (1.5) | 8-12 | PSA |
| 2147 | N | 0.060 (1.5) | 8-12 | |
| 2038 | R | 0.060 (1.5) | 8-12 | PSA |
| 2263 | R | 0.060 (1.5) | 8-12 | |
| 2261 | S | 0.060 (1.5) | 8-12 | PSA |
| 2240 | S | 0.060 (1.5) | 8-12 | FR-PSA |
| 2239 | S | 0.060 (1.5) | 8-12 | FR |
| 2221 | S | 0.060 (1.5) | 8-12 | |
| 2116 | W | 0.060 (1.5) | 8-12 | PSA |
| 2117 | W | 0.060 (1.5) | 8-12 | GP |

| NUMBER | MATERIAL TYPE | THICKNESS IN (MM) | OPT. FREQ. RANGE (GHZ) * | OTHER |
|---|---|---|---|---|
| 2115 | W | 0.060 (1.5) | 8-12 | |
| 2134 | R | 0.055 (1.4) | 8-12 | PSA |
| 2133 | R | 0.055 (1.4) | 8-12 | |
| 2158 | U | 0.055 (1.4) | 8-12 | |
| 2113 | N | 0.052 (1.3) | 8-12 | PSA |
| 2003 | N | 0.052 (1.3) | 8-12 | FESI |
| 2169 | N | 0.052 (1.3) | 8-12 | |
| 2269 | V | 0.052 (1.3) | 8-12 | FESI |
| 2008 | V | 0.052 (1.3) | 8-12 | |
| 2056 | N | 0.050 (1.3) | 8-12 | PSA |
| 2057 | N | 0.050 (1.3) | 8-12 | GP-PSA |
| 2281 | N | 0.050 (1.3) | 8-12 | FESI |
| 2098 | N | 0.045 (1.1) | 8-12 | FESI |
| 2093 | N | 0.045 (1.1) | 8-12 | |
| 2036 | V | 0.045 (1.1) | 8-12 | FESI |
| 2035 | V | 0.045 (1.1) | 8-12 | |
| 2105 | R | 0.044 (1.1) | 8-12 | |
| 2153 | S | 0.044 (1.1) | 8-12 | |
| 2168 | N | 0.043 (1.1) | 8-12 | |
| 2143 | N | 0.040 (1.0) | 8-12 | PSA |
| 2099 | N | 0.040 (1.0) | 8-12 | |
| 2031 | R | 0.040 (1.0) | 8-12 | PSA |
| 2146 | R | 0.040 (1.0) | 8-12 | |
| 2218 | S | 0.040 (1.0) | 8-12 | PSA |
| 2238 | S | 0.040 (1.0) | 8-12 | FR-PSA |
| 2237 | S | 0.040 (1.0) | 8-12 | FR |
| 2270 | S | 0.040 (1.0) | 8-12 | |
| 2224 | U | 0.040 (1.0) | 8-12 | PSA |
| 2028 | N | 0.038 (1.0) | 12-18 | GP |
| 2252 | S | 0.036 (0.9) | 12-18 | FR-PSA |
| 2251 | S | 0.036 (0.9) | 12-18 | FR |
| 2204 | N | 0.035 (0.9) | 12-18 | PSA |
| 2260 | N | 0.035 (0.9) | 12-18 | |
| 2183 | U | 0.035 (0.9) | 12-18 | PSA |
| 2243 | U | 0.035 (0.9) | 12-18 | |
| 2283 | N | 0.032 (08) | 12-18 | FESI-PSA |
| 2282 | N | 0.032 (08) | 12-18 | FESI |
| 2045 | N | 0.030 (0.8) | 12-18 | PSA |
| 2191 | N | 0.030 (0.8) | 12-18 | GP |
| 2132 | N | 0.030 (0.8) | 12-18 | FESI |
| 2181 | N | 0.030 (0.8) | 12-18 | |
| 2277 | R | 0.030 (0.8) | 12-18 | FESI |
| 2151 | R | 0.030 (0.8) | 12-18 | |
| 2152 | S | 0.030 (0.8) | 12-18 | PSA |
| 2236 | S | 0.030 (0.8) | 12-18 | FR-PSA |
| 2235 | S | 0.030 (0.8) | 12-18 | FR |
| 2046 | S | 0.030 (0.8) | 12-18 | |
| 2144 | R | 0.028 (0.7) | 12-18 | PSA |
| 2119 | S | 0.028 (0.7) | 12-18 | |
| 2140 | N | 0.027 (0.7) | 12-18 | |
| 2078 | N | 0.025 (0.6) | 12-18 | |
| 2136 | S | 0.025 (0.6) | 12-18 | |
| 2053 | N | 0.020 (0.5) | 12-18 | PSA |
| 2201 | R | 0.020 (0.5) | 12-18 | PSA |
| 2112 | R | 0.020 (0.5) | 12-18 | |
| 2120 | S | 0.020 (0.5) | 12-18 | PSA |
| 2234 | S | 0.020 (0.5) | 12-18 | FR-PSA |
| 2233 | S | 0.020 (0.5) | 12-18 | FR |
| 2075 | S | 0.020 (0.5) | 12-18 | |
| 2187 | U | 0.020 (0.5) | 12-18 | |
| 2966 | S | 0.015 (0.4) | 12-18 | PSA |
| 2963 | S | 0.012 (0.3) | 12-18 | PSA |
| 2960 | S | 0.010 (0.3) | 12-18 | PSA |

* Adequate surface wave performance may be achieved by using thinner materials. Consult R&F Products applications engineers for assistance.

All dimensions shown are in inches (millimeters) unless otherwise specified.

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# RFRET – RETICULATED FOAM ABSORBERS

RFRET is reticulated foam absorber. Reticulated foam is a urethane-based foam with a well-defined open-cell structure. The cell size can be chosen to optimize penetration of the conductive coating to which it is adhered. R&F uses two separate processes to produce its reticulated foam absorber. Our unique spray process applies a coating that is graded through the thickness of the foam. The grading of the coating also produces an electrical grading that results in a material with excellent broadband reflectivity reduction.

R&F also uses a dip process to produce foam with uniform electrical properties. This type of foam is described in more detail in the LS foam section on page 13. RFRET–LS is produced to a specific insertion loss (dB/in.) at a specific frequency (generally 3 or 10GHz).

R&F also dips RFRET-CV, a convoluted egg-crate shaped foam. This shaping allows for the graded impedance, which provides broadband reflectivity reduction. RFRET-CV is produced in thicknesses from 1.5" to 4" (38.1 mm to 101.6 mm) and is used when broadband performance from 2 to 18GHz is required. The product can be supplied with a bonded-on ground plane and pressure-sensitive adhesive.

## APPLICATIONS

RFRET broadband foam is commonly used around antennas to provide isolation or side lobe reduction. It can be die-cut into components for EMI reduction inside microwave cavities and is used to manufacture antenna hats and test boxes. It can be encapsulated into a textile cover for use outdoors and fabricated into blankets, covers and other components. Recently, it has been used for a combination air/EMI filter in networking equipment. The product can be made UL94 HF1 for such applications.



FIGURE 2.

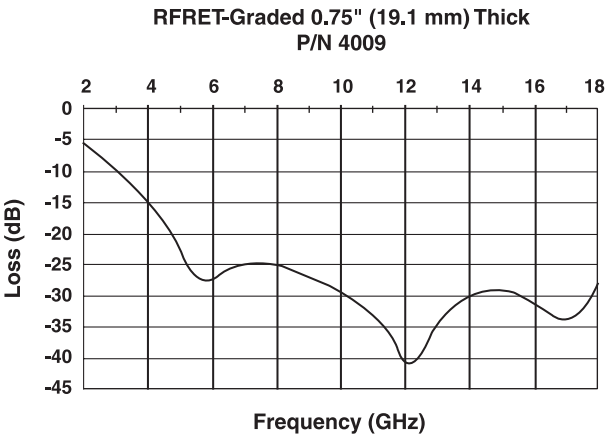



FIGURE 1.

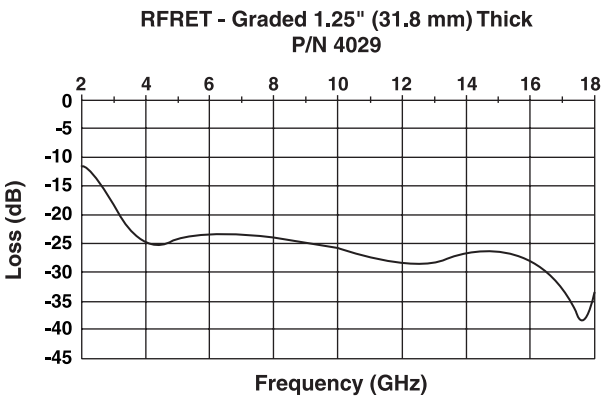
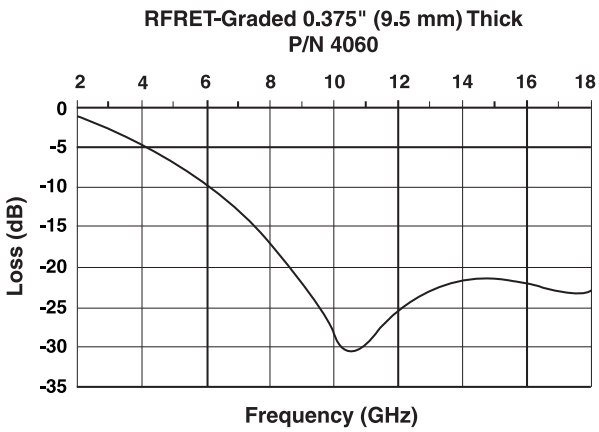



FIGURE 3.




## ORDERING INFORMATION

Tables 1-3, on page 12, provide ordering information and existing part numbers for three types of reticulated foam absorbers: RFRET–Graded Coating, RFRET– Uniform Coating and RFRET/CV Convoluted Reticulated Foam.

## RFRET – GRADED COATING

Select desired frequency range, noting thickness (in ascending order) from Table 1. The base part number determines the length, width and frequency range. The other options column indicates flame retardant (FR), pressure-sensitive adhesive (PSA) or ground plane (GP).

All dimensions shown are in inches (millimeters) unless otherwise specified.

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## TABLE 1: RFRET – GRADED COATING PART NUMBERS

Note: Other combinations of attributes or materials are available; please contact sales for assistance.

### 4000 – 4299 RFRET – GRADED COATING

| PART NUMBER | THICKNESS IN (MM) | LENGTH IN (MM) | WIDTH IN (MM) | FREQ. RANGE (GHZ) -20DB | OTHER |
|---|---|---|---|---|---|
| 4044 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | 12-18 | FR |
| 4032 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | 12-18 | |
| 4054 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | 10-18 | |
| 4050 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | 10-18 | FR |
| 4000 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | 10-18 | |
| 4078 | 0.375 (9.5) | 48.0 (1219.2) | 24.0 (609.6) | 10-18 | GP |
| 4058 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | 10-18 | GP-PSA |
| 4060 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | 10-18 | PSA |
| 4074 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | 8-18 | |
| 4001 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | 8-18 | |
| 4014 | 0.500 (12.7) | 96.0 (2438.4) | 24.0 (609.6) | 8-18 | |
| 4056 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | 8-18 | GP |
| 4002 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | |
| 4012 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | |
| 4006 | 0.750 (19.1) | 96.0 (2438.4) | 24.0 (609.6) | 6-18 | |
| 4009 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | |
| 4038 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | |
| 4022 | 0.750 (19.1) | 59.0 (1498.6) | 24.0 (609.6) | 6-18 | |
| 4043 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | GP |
| 4059 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | PSA |
| 4062 | 1.000 (25.4) | 24.0 (609.6) | 24.0 (609.6) | 5-18 | |
| 4036 | 1.125 (28.6) | 60.0 (1524.0) | 30.0 (762.0) | 4-18 | |
| 4037 | 1.125 (28.6) | 96.0 (2438.4) | 30.0 (762.0) | 4-18 | |
| 4003 | 1.125 (28.6) | 24.0 (609.6) | 24.0 (609.6) | 4-18 | |
| 4015 | 1.125 (28.6) | 24.0 (609.6) | 24.0 (609.6) | 4-18 | GP |
| 4029 | 1.250 (31.8) | 24.0 (609.6) | 24.0 (609.6) | 4-18 | |
| 4071 | 1.250 (31.8) | 24.0 (609.6) | 24.0 (609.6) | 4-18 | GP-PSA |
| 4076 | 1.250 (31.8) | 24.0 (609.6) | 24.0 (609.6) | 4-18 | PSA |
| 4021 | 1.500 (38.1) | 24.0 (609.6) | 24.0 (609.6) | 4-18 | |
| 4073 | 2.000 (50.8) | 40.0 (1016.0) | 30.0 (762.0) | 2-18 | |
| 4020 | 2.000 (50.8) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |
| 4051 | 2.000 (50.8) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | FR |
| 4024 | 2.000 (50.8) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |
| 4026 | 2.000 (50.8) | 60.0 (1524.0) | 30.0 (762.0) | 2-18 | |
| 4077 | 2.000 (50.8) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | GP |
| 4040 | 3.000 (76.2) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |

## RFRET–UNIFORM COATING

Table 2 shows existing part numbers for uniform reticulated foam materials. Select the desired thickness and part number. Within a given thickness, the insertion loss can be tailored by the addition of more of the conductive carbon coating. Performance is measured in dB insertion loss compared to air either at 3 or 10GHz. The other column indicates flame retardancy (FR), pressure-sensitive adhesive (PSA) or ground plane (GP).

Standard sheet size is 24" x 24" (609.6 mm x 609.6 mm); other sizes are also available.

All dimensions shown are in inches (millimeters) unless otherwise specified.

## TABLE 2: RFRET – UNIFORM COATING RETICULATED FOAM PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

### 4300 – 4399 RFRET – UNIFORM COATING

| PART NUMBER | THICKNESS IN (MM) | LENGTH IN (MM) | WIDTH IN (MM) | INSERTION LOSS AT 3GHZ (DB/IN) | INSERTION LOSS AT 10GHZ (DB/IN) | OTHER |
|---|---|---|---|---|---|---|
| 4312 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | | -8.0 | |
| 4313 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | | -12.0 | |
| 4341 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | | -49.0 | PSA |
| 4308 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | | -68.0 | |
| 4340 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | | -76.0 | |
| 4314 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | | -18.0 | |
| 4315 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | -40.0 | | |
| 4316 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | -20.0 | | |
| 4318 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | -40.0 | | |
| 4347 | 1.000 (25.4) | 24.0 (609.6) | 24.0 (609.6) | -10.5 | | |
| 4320 | 1.000 (25.4) | 24.0 (609.6) | 24.0 (609.6) | -11.5 | | |
| 4346 | 1.000 (25.4) | 24.0 (609.6) | 24.0 (609.6) | -5.0 | | |

## RFRET/CV – CONVOLUTED RETICULATED FOAM

Table 3 lists existing part numbers for convoluted reticulated foam materials. Select the desired frequency range and thickness and determine the part number. The thicker the foam material, the broader the frequency ranges of coverage. Performance is nominally –20dB reflectivity reduction over the frequency range listed. Standard sheet size is 24" x 24" (609.6 mm x 609.6 mm); other sizes are also available.

## TABLE 3: RFRET/CV – CONVOLUTED RETICULATED FOAM PART NUMBERS



Note: Other materials or combinations of attributes are available; please contact sales for assistance.

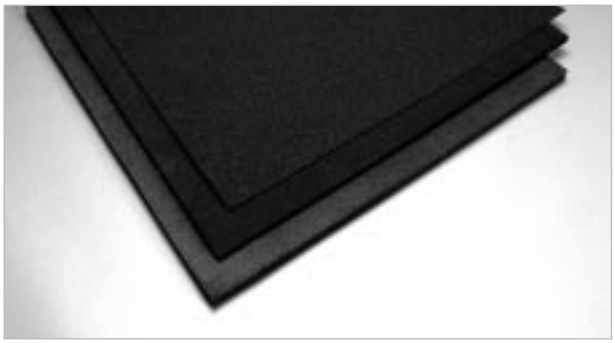
### 4500-4599 RFRET/CV – CONVOLUTED RETICULATED FOAM

| PART NUMBER | THICKNESS IN (MM) | LENGTH IN (MM) | WIDTH IN (MM) | FREQ. RANGE (GHZ) -20DB | OTHER |
|---|---|---|---|---|---|
| 4506 | 1.500 (38.1) | 24.0 (609.6) | 24.0 (609.6) | 4-18 | |
| 4507 | 1.500 (38.1) | 24.0 (609.6) | 48.0 (1219.2) | 4-18 | |
| 4511 | 1.500 (38.1) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | FR |
| 4513 | 2.000 (50.8) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |
| 4514 | 2.000 (50.8) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | GP |
| 4500 | 2.500 (63.5) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |
| 4509 | 2.500 (63.5) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |
| 4503 | 2.750 (69.9) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |
| 4501 | 3.000 (76.2) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |
| 4504 | 3.000 (76.2) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |
| 4512 | 3.000 (76.2) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | PSA |
| 4502 | 4.000 (101.6) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | |
| 4505 | 4.000 (101.6) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | PSA |
| 4510 | 4.000 (101.6) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | GP |

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# RFLS – SINGLE LAYER "LOSSY" FOAM ABSORBERS

RFLS is a series of single layer "lossy" sheets produced by dipping lightweight open-celled urethane foam into a resistive solution. The end product is a uniform, lightweight, loaded sheet material with a specified insertion loss at a given frequency. RFLS offers the lowest cost in microwave absorber products. Thickness of the sheets range from 0.125" to 1.5" (3.2 mm to 38.1 mm) and are generally 24" x 24" (609.6 mm x 609.6 mm). Custom sizes and components can be fabricated. The insertion loss of the product is measured in an insertion tunnel over the 2 to 18GHz frequency range. Specifications are generally given at 3 or 10GHz. The material can be die-cut into components and supplied with a pressure-sensitive adhesive for ease of application.



## APPLICATIONS

RFLS sheets are used to lower noise or cavity Q's in microwave components such as amplifiers, oscillators, computer housings and wireless equipment. Fire retardant versions to UL94 HF1 are also available.

FIGURE 1.

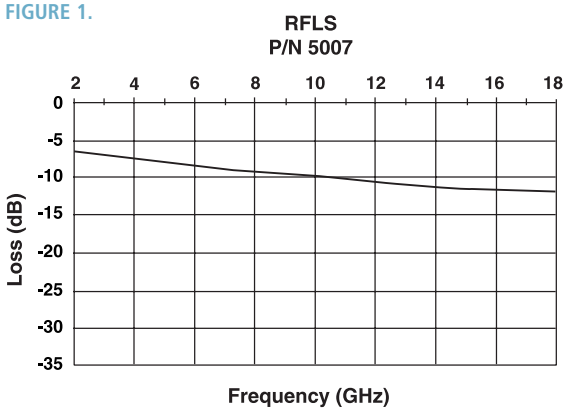
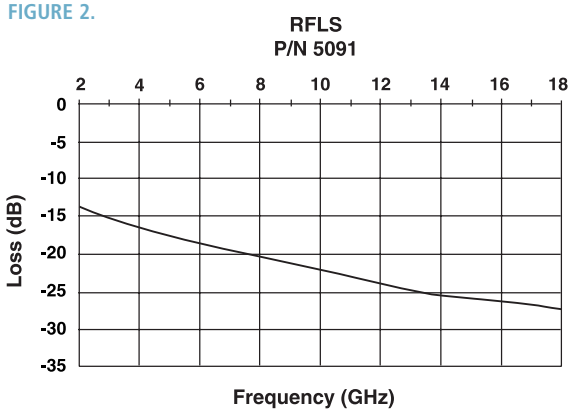



FIGURE 2.




## ORDERING INFORMATION

Table 1 lists existing part numbers for uniform LS foam materials. Select the thickness (in ascending order) and the part number. Within a given thickness, the insertion loss can be tailored by the addition of more of the conductive carbon coating. The other columns indicate flame retardant (FR), pressure-sensitive adhesive (PSA) or ground plane (GP). Performance is measured in dB insertion loss compared to air at 3GHz. Standard sheet size is 24" x 24" (609.6 mm x 609.6 mm); other sizes are also available.

All dimensions shown are in inches (millimeters) unless otherwise specified.

## TABLE 1: RFLS – SINGLE LAYER "LOSSY" SHEETS PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

### 5000 – 5299 RFLS – SINGLE LAYER "LOSSY" SHEETS

| PART NUMBER | THICKNESS IN (MM) | LENGTH IN (MM) | WIDTH IN (MM) | INSERTION LOSS PER IN AT 3GHZ (DB/IN) | OTHER |
|---|---|---|---|---|---|
| 5020 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -7.8 | |
| 5047 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -10.0 | |
| 5072 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -15.0 | |
| 5093 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -15.0 | PSA |
| 5049 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -32.0 | |
| 5073 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -38.0 | PSA |
| 5040 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -46.0 | |
| 5099 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -46.0 | |
| 5098 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -50.0 | |
| 5062 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -60.0 | |
| 5065 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -67.0 | |
| 5063 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -84.0 | |
| 5064 | 0.125 (3.2) | 24.0 (609.6) | 24.0 (609.6) | -104.0 | |
| 5002 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -1.1 | |
| 5007 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -1.7 | |
| 5006 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -2.5 | |
| 5005 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -3.8 | |
| 5082 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -4.1 | |
| 5008 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -5.9 | |
| 5009 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -7.8 | |
| 5081 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -10.0 | |
| 5003 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -32.0 | |
| 5079 | 0.250 (6.4) | 108.0 (2743.2) | 24.0 (609.6) | -32.0 | |
| 5004 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -39.0 | |
| 5010 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -46.0 | |
| 5016 | 0.250 (6.4) | 110.0 (2794.0) | 19.0 (482.6) | -49.0 | |
| 5092 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -49.0 | |
| 5011 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -58.0 | PSA |
| 5012 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -67.0 | PSA |
| 5001 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | -76.0 | |
| 5048 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | -10.0 | |
| 5017 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | -15.0 | |
| 5060 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | -32.0 | |
| 5078 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | -39.0 | |
| 5021 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | -46.0 | |
| 5066 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | -67.0 | |
| 5095 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | -6.5 | |
| 5089 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | -25.0 | |
| 5090 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | -25.0 | PSA |
| 5067 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | -67.0 | |
| 5014 | 1.000 (25.4) | 24.0 (609.6) | 24.0 (609.6) | -13.0 | |
| 5091 | 1.000 (25.4) | 24.0 (609.6) | 24.0 (609.6) | -15.0 | |
| 5086 | 1.000 (25.4) | 24.0 (609.6) | 24.0 (609.6) | -30.0 | |
| 5059 | 1.250 (31.8) | 24.0 (609.6) | 24.0 (609.6) | -10.0 | PSA |
| 5068 | 4.000 (101.6) | 24.0 (609.6) | 24.0 (609.6) | -1.5 | |
| 5069 | 4.000 (101.6) | 24.0 (609.6) | 24.0 (609.6) | -2.0 | |
| 5070 | 4.000 (101.6) | 24.0 (609.6) | 24.0 (609.6) | -3.0 | |
| 5071 | 4.000 (101.6) | 24.0 (609.6) | 24.0 (609.6) | -4.0 | |

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# RFML – MULTILAYER FOAM ABSORBERS

RFML is a multilayer foam absorber consisting of three sheets of RFLS material. The layers vary in insertion loss from the front to the back of the material. For example, RFML–75 is 0.75" (19.1 mm) thick and consists of three layers of RFLS 0.25" (6.4 mm) bonded together. The top layer is very lightly loaded to provide a good impedance match to free space. This matching layer reduces the energy reflected off the surface of the material. The second and third layers have increasing loss and the net effect is a material that has broadband reflectivity reduction.

The thickness range of the RFML product is 0.375" to 4.5" (9.5 mm x 114.3 mm), and the standard sheet size is 24" x 24" (609.6 mm x 609.6 mm). The foam can be cut with a band saw or electric knife into final shape.

The material can be supplied with a bonded-on ground plane and pressure-sensitive adhesive. It can also be supplied weatherproof by bonding a neoprene or vinyl fabric to the material.

## APPLICATIONS

RFML is used to reduce cross talk between antennas and reduce antenna side lobes. It can also be used in chambers to minimize reflections from test equipment and other objects in the field of measurement. While the attenuation is not as deep and flat as the RFRET graded product, its higher density makes it the absorber of choice in many applications.

FIGURE 1.

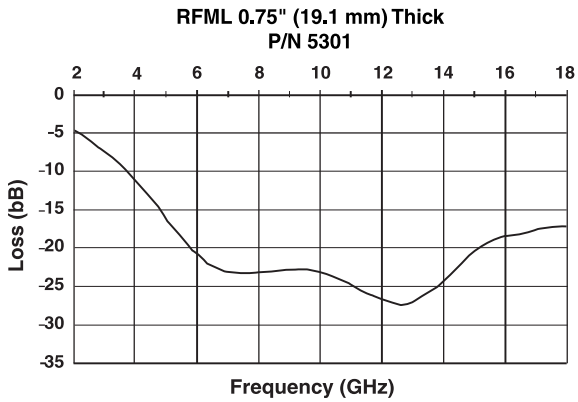
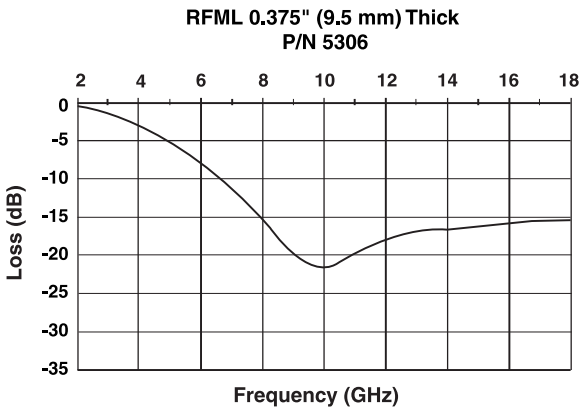
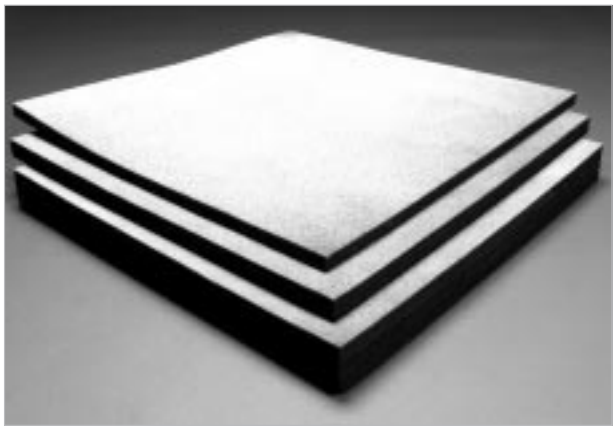



FIGURE 2.




All dimensions shown are in inches (millimeters) unless otherwise specified.



## ORDERING INFORMATION

Table 1 lists the existing part numbers for broadband multilayer absorbers. Select the desired frequency range, noting thickness (in ascending order). The base part number determines the length, width and frequency range. The other column indicates pressure-sensitive adhesive (PSA) and ground plane (GP).

Performance is nominally >-15dB reflectivity reduction over the frequency range listed. Standard sheet size is 24" x 24" (609.6 mm x 609.6 mm).

## TABLE 1: RFML – MULTILAYER ABSORBER PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

### 5300 – 5599 RFML – MULTILAYER ABSORBERS

| PART NUMBER | THICKNESS IN (MM) | LENGTH IN (MM) | WIDTH IN (MM) | FREQ RANGE (GHZ) | DB LOSS | OTHER |
|---|---|---|---|---|---|---|
| 5305 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | 12-18 | -15 | |
| 5311 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | 8-18 | -15 | PSA |
| 5309 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | 8-18 | -15 | GP-PSA |
| 5314 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | 8-18 | -15 | FR |
| 5306 | 0.375 (9.5) | 24.0 (609.6) | 24.0 (609.6) | 8-18 | -15 | |
| 5312 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | -15 | PSA |
| 5310 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | -15 | GP-PSA |
| 5313 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | -15 | GP |
| 5301 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 6-18 | -15 | |
| 5307 | 1.125 (28.6) | 24.0 (609.6) | 24.0 (609.6) | 4-18 | -15 | PSA |
| 5303 | 1.125 (28.6) | 24.0 (609.6) | 24.0 (609.6) | 4-18 | -15 | |
| 5300 | 2.250 (57.2) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | -15 | |
| 5308 | 4.500 (114.3) | 24.0 (609.6) | 24.0 (609.6) | < 2-18 | -15 | |

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# RFRIGID – STRUCTURAL MICROWAVE ABSORBING FOAM

R&F manufactures a structural foam family with microwave absorbing properties. It is based on the RFRET reticulated foam absorber. RFRET is an excellent free-space absorber, but lacks toughness and environmental resistance. Because RFRET is open-celled, it can be filled with closed-celled structural foam to form RFRIGID. Three standard fillers are used: rigid urethane, flexible urethane and epoxy. The resulting products range from 10 to 20 pounds per cubic foot density and offer a structural, environmentally tough panel. The materials can be molded to shape, machined or bonded into complex covers and shapes.
If skins are applied, rigid lightweight structural panels are formed.

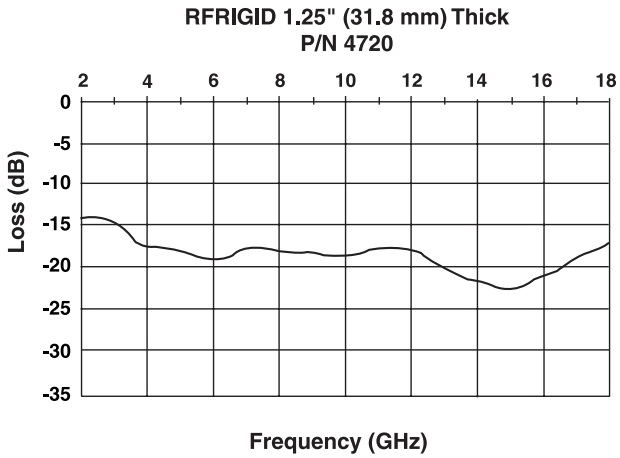
R&F has also developed new types of foam, including syntactic foam and phenolic foams. Contact an R&F applications engineer for more detail on what can be achieved.

## APPLICATIONS

The ability to customize the mechanical and electrical properties of the foam allow for a wide range of applications including:

- Absorptive pucks for spiral antenna cavities
- Fairings for vehicles and radars
- Antenna housings
- Lightweight microwave absorbing barriers

FIGURE 1.




## ORDERING INFORMATION

Table 1 shows existing standard part numbers for RFRIGID products. From the table, select desired thickness (in ascending order). The part number determines the material type, length, width and frequency range of operation. The other column lists the closed-cell foam that is used to fill the reticulated foam. The thicker the foam material, the broader the frequency ranges of coverage. Performance is nominally –17 to –20dB reflectivity reduction over the frequency range listed.

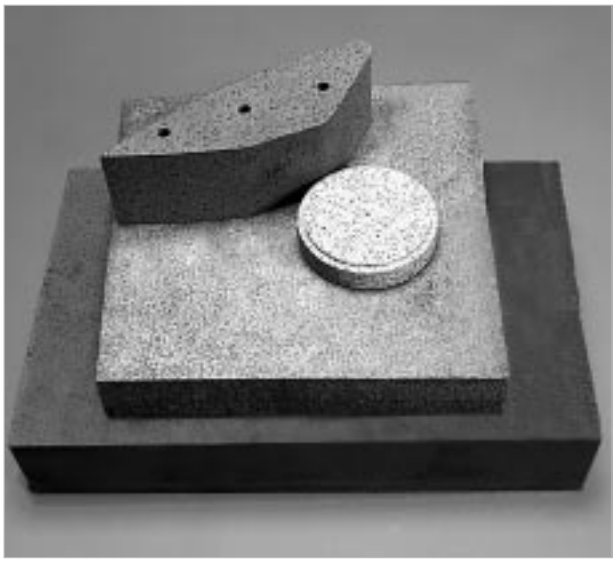
### Available Fill Foam Materials are:

RU – Rigid Urethane

FU – Flexible Urethane

E – Epoxy

S – Syntactic Urethane



## TABLE 1: RFRIGID – STRUCTURAL MICROWAVE ABSORBING FOAM PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

### 4700 – 4799 RFRIGID – STRUCTURAL MICROWAVE ABSORBING FOAM

| PART NUMBER | THICKNESS IN (MM) | LENGTH IN (MM) | WIDTH IN (MM) | FREQ. RANGE (GHZ) -17DB | MATERIAL |
|---|---|---|---|---|---|
| 4731 | 0.420 (10.7) | 24.0 (609.6) | 24.0 (609.6) | 7-18 | RU |
| 4740 | 0.440 (11.2) | 24.0 (609.6) | 24.0 (609.6) | 7-18 | FU |
| 4738 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | 7-18 | E |
| 4739 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | 7-18 | E |
| 4709 | 0.700 (17.8) | 24.0 (609.6) | 24.0 (609.6) | 5-18 | RU |
| 4701 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 5-18 | RU |
| 4710 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 5-18 | RU |
| 4703 | 1.000 (25.4) | 12.0 (304.8) | 12.0 (304.8) | 3-18 | RU |
| 4746 | 1.000 (25.4) | 48.0 (1219.2) | 36.0 (914.4) | 3-18 | E |
| 4711 | 1.250 (31.8) | 24.0 (609.6) | 24.0 (609.6) | 3-18 | RU |
| 4712 | 1.250 (31.8) | 24.0 (609.6) | 24.0 (609.6) | 3-18 | RU |
| 4720 | 1.250 (31.8) | 48.0 (1219.2) | 36.0 (914.4) | 3-18 | E |
| 4730 | 1.250 (31.8) | 24.0 (609.6) | 36.0 (914.4) | 3-18 | RU |
| 4743 | 1.250 (31.8) | 10.0 (254.0) | 10.0 (254.0) | 3-18 | S |
| 4741 | 1.300 (33.0) | 12.0 (304.8) | 12.0 (304.8) | 3-18 | RU |
| 4734 | 2.000 (50.8) | 24.0 (609.6) | 24.0 (609.6) | 2-18 | RU |
| 4736 | 2.000 (50.8) | 36.0 (914.4) | 12.0 (304.8) | 2-18 | RU |

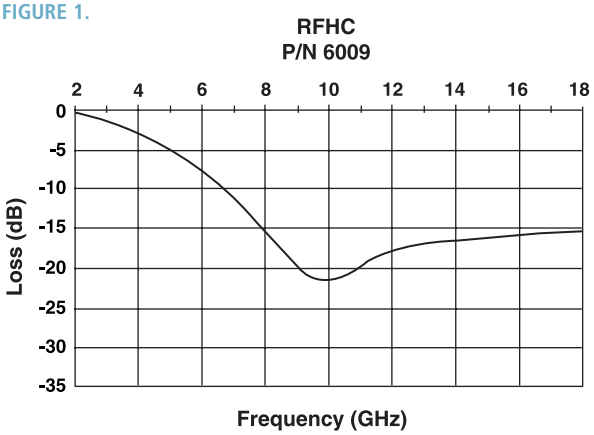
All dimensions shown are in inches (millimeters) unless otherwise specified.

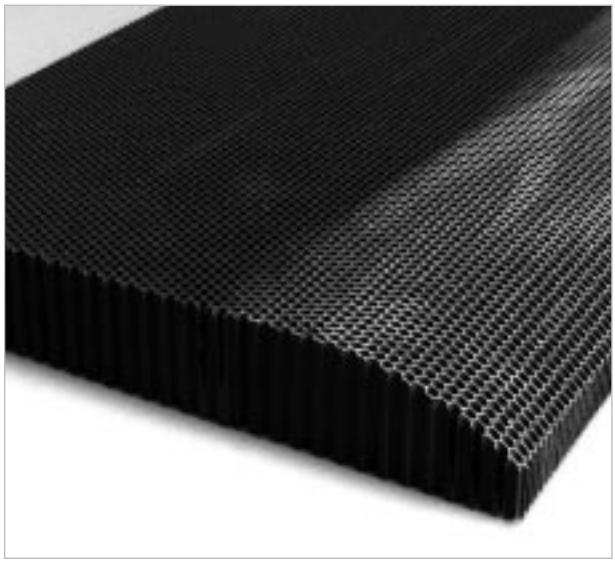
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# RFHC – TREATED HONEYCOMB CORE ABSORBERS

RFHC is a broadband microwave absorbing honeycomb core material. R&F uses either Nomex® or fiberglass honeycomb core and applies a "lossy" coating to it. The RF core can have a uniform coating to optimize insertion loss or a graded coating to optimize reflection loss. The cell sizes generally used are 0.125" to 0.187" (3.2 mm to 4.8 mm) thick with densities of 3 to 4 lb./ft$^3$. The performance curve in Figure 1 shows the typical performance of a 0.5" (12.7 mm) thick core, providing good attenuation over a broad frequency range. We can optimize the performance to account for laminated skins or core and can assist in selecting the right materials to minimize performance degradation.

FIGURE 1.



## APPLICATIONS

RFHC materials are used as "lossy" loads in spiral antennas and high-power antenna couplers. They are used with laminated skins to manufacture radar absorbing structural (RAS) panels and components. Our engineering staff can help design a material that meets your special requirements.

## ORDERING INFORMATION

Table 1 lists the existing part numbers for broadband microwave absorbing honeycomb core material. Select the desired thickness (in ascending order), noting the desired frequency range. Select a cell size and density and the base part number. The base part number determines the length, width, density in terms of pounds per cubic foot (PCF), cell size and frequency range.

The thicker the core material, the broader the frequency ranges of coverage. Performance is nominally –17dB reflectivity reduction over the frequency range listed. The cell size of the honeycomb core is generally 0.125" to 0.187" (3.2 mm to 4.8 mm) with a core type of either Nomex or fiberglass.

## TABLE 1: RFHC – TREATED HONEYCOMB CORE PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

### 6000 – 6799 RFHC – TREATED HONEYCOMB CORE

| PART NUMBER | THICKNESS IN (MM) | LENGTH IN (MM) | WIDTH IN (MM) | DENSITY (PSF) | CELL SIZE IN (MM) | FREQ |
|---|---|---|---|---|---|---|
| 6017 | 0.500 (12.7) | 24.0 (609.6) | 24.0 (609.6) | 3.0 | 0.187 (4.8) | 8-18 |
| 6003 | 0.500 (12.7) | 12.0 (304.8) | 12.0 (304.8) | 3.0 | 0.250 (6.4) | 8-18 |
| 6009 | 0.500 (12.7) | 12.0 (304.8) | 12.0 (304.8) | 4.0 | 0.125 (3.2) | 8-18 |
| 6000 | 0.500 (12.7) | 12.0 (304.8) | 12.0 (304.8) | 3.0 | 0.187 (4.8) | 8-18 |
| 6007 | 0.500 (12.7) | 16.0 (406.4) | 18.0 (457.2) | 4.0 | 0.187 (4.8) | 8-18 |
| 6008 | 0.500 (12.7) | 12.0 (304.8) | 12.0 (304.8) | 4.0 | 0.187 (4.8) | 8-18 |
| 6011 | 0.500 (12.7) | 12.0 (304.8) | 12.0 (304.8) | 4.0 | 0.187 (4.8) | 8-18 |
| 6050 | 0.625 (15.9) | 24.0 (609.6) | 24.0 (609.6) | 4.0 | 0.187 (4.8) | 8-18 |
| 6005 | 0.670 (17.0) | 12.0 (304.8) | 12.0 (304.8) | 4.0 | 0.187 (4.8) | 6-18 |
| 6049 | 0.750 (19.1) | 24.0 (609.6) | 24.0 (609.6) | 4.0 | 0.187 (4.8) | 6-18 |
| 6002 | 0.750 (19.1) | 12.0 (304.8) | 12.0 (304.8) | 3.0 | 0.125 (3.2) | 6-18 |
| 6021 | 0.813 (20.7) | 12.0 (304.8) | 12.0 (304.8) | 3.0 | 0.187 (4.8) | 6-18 |
| 6004 | 0.877 (22.3) | 12.0 (304.8) | 12.0 (304.8) | 3.0 | 0.187 (4.8) | 6-18 |
| 6013 | 1.200 (30.5) | 24.0 (609.6) | 24.0 (609.6) | 4.0 | 0.125 (3.2) | 4-18 |
| 6010 | 1.250 (31.8) | 12.0 (304.8) | 12.0 (304.8) | 4.0 | 0.125 (3.2) | 4-18 |
| 6051 | 1.750 (44.5) | 13.0 (330.2) | 13.0 (330.2) | 3.0 | 0.187 (4.8) | 4-18 |
| 6006 | 2.000 (50.8) | 30.0 (762.0) | 30.0 (762.0) | 1.8 | 0.125 (3.2) | 2-18 |
| 6037 | 2.065 (52.5) | 10.0 (254.0) | 15.0 (381.0) | 3.0 | 0.187 (4.8) | 2-18 |
| 6025 | 2.500 (63.5) | 24.0 (609.6) | 24.0 (609.6) | 2.0 | 0.187 (4.8) | 2-18 |
| 6038 | 3.500 (88.9) | 12.0 (304.8) | 12.0 (304.8) | 3.0 | 0.187 (4.8) | 2-18 |

All dimensions shown are in inches (millimeters) unless otherwise specified.

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# RFSS – SALISBURY SCREENS

RFSS screen absorbers are thin, extremely lightweight absorbers that are optimized to provide a high degree of absorption for specific frequencies in the range of 1 to 18GHz.

Construction consists of a conductive carbon coated "lossy" fabric, separated from a conductive ground plane by a low dielectric foam core. As a tuned (narrowband) absorber, the material must have an electrical thickness of 1/4 of a wavelength at the frequency of operation. This promotes signal attenuation by both energy dissipation within the "lossy" fabric material, as well as cancellation of the incoming and emerging signals at the surface, where they are 180° out of phase.

Through accurate control of the coating process used for the "lossy" fabric, absorption levels of greater than 20dB are easily and consistently achieved with a 10% bandwidth at the specified operating frequency.

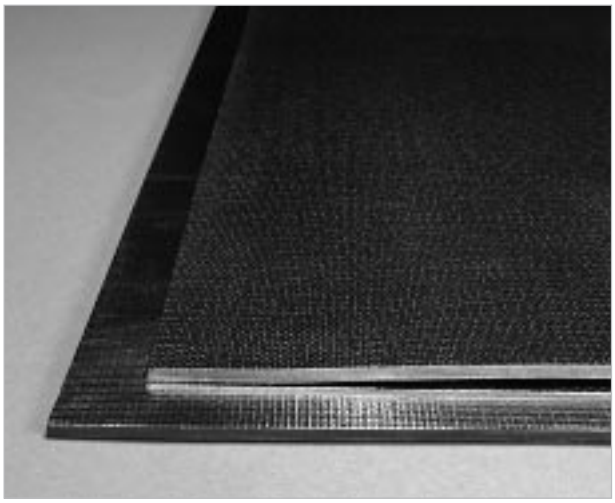
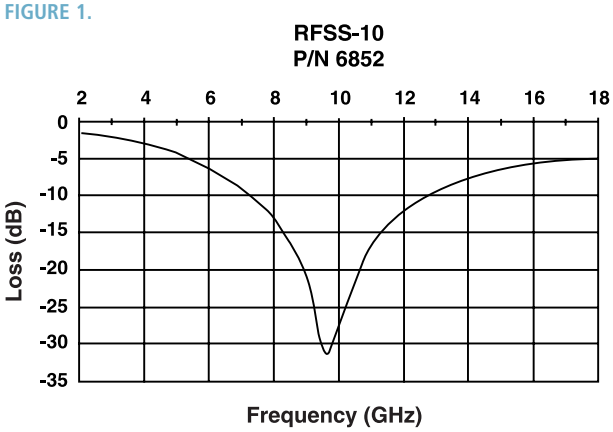


FIGURE 1.




## APPLICATIONS

This material is primarily used in airborne applications where weight savings are essential. It is used to reduce the interfering reflections in airborne radar applications or any antenna or signal environment that requires the suppression of random reflections at specified frequencies.

To facilitate installation in application-specific areas, this material is readily supplied die-cut to specific shapes and sizes.

## ORDERING INFORMATION

Table 1 shows existing standard part number configurations. Select the desired frequency and part number. The part number designates the thickness, length, width and frequency range. The other column indicates the use of pressure-sensitive adhesive.

## TABLE 1: RFSS – SALISBURY SCREEN PART NUMBERS

Note: Other materials or combinations of attributes are available; please contact sales for assistance.

### 6800 – 6999 RFSS – SALISBURY SCREENS

| PART NUMBER | THICKNESS IN (MM) | LENGTH IN (MM) | WIDTH IN (MM) | FREQ. RANGE (GHZ) -20DB | OTHER |
|---|---|---|---|---|---|
| 6827 | 0.540 (13.7) | 24.0 (609.6) | 24.0 (609.6) | 5.4 | |
| 6802 | 0.250 (6.4) | 96.0 (2438.4) | 48.0 (1219.2) | 9 | |
| 6803 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | 9 | |
| 6847 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | 9.4 | |
| 6848 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | 9.4 | PSA |
| 6852 | 0.250 (6.4) | 24.0 (609.6) | 24.0 (609.6) | 10 | |
| 6814 | 0.180 (4.6) | 24.0 (609.6) | 24.0 (609.6) | 16.7 | |

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All dimensions shown are in inches (millimeters) unless otherwise specified.

# MICROWAVE ABSORBING TEXTILE COVERS



Absorbing textile antenna covers.



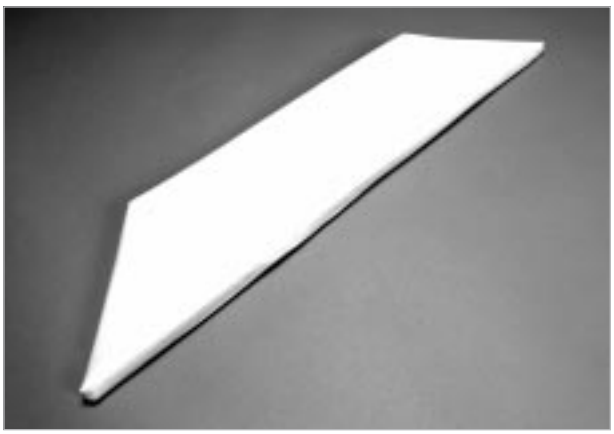
Complete capability for manufacturing microwave absorbing textiles.

R&F Products has the capability to integrate microwave absorbing or reflecting properties into custom covers, screens and other textile products. Applications for these products include:

- Test blankets for shipboard EMI
- Diagnostics for PCS antenna installations
- Covers for radomes, hangar doors or other ship articles
- Covers for guns, turrets or other vehicle articles
- Tents and equipment housings
- Personnel clothing and covers
- Cushions and boat articles

Many of these products are based upon R&F Products RFRET foam material. RFRET is open-celled lightweight foam, which is flexible and provides excellent broadband microwave absorption. The absorber can be sewn or RF welded into different textile materials. The textile cover is chosen based upon the environmental properties desired. Vinyl, neoprene, silicone and Hypalon® are commonly used materials. Reinforcements include nylon, fiberglass, polyester and Kevlar®. A variety of attachment schemes can be used including Velcro®, zippers, buckles, tie downs and other standard attachments.

Camouflage materials can also be used to provide both RF and visual protection. The foam works equally well at millimeter wave frequencies. R&F is working with other companies to provide infrared protection and integrate conductive materials into fabric coatings. A variety of conductive materials are available including Flectron nickel/copper coated fabric, aluminized glass mat, lightweight scrims and wire screens.



Fabric covered foam for weatherproof applications.



Custom fabric coated RFML absorber.

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All dimensions shown are in inches (millimeters) unless otherwise specified.

# CUSTOM MAGNETIC ABSORBERS

R&F Products is the leader in the compression molding of elastomeric magnetic sheet materials. The single band, surface wave and multiband types of absorbers have magnetic fillers mixed into gum elastomers and are subsequently compression molded into flat sheets or conformal shapes. The end product is tightly controlled for electrical properties and is a very robust material capable of being die-cut into a variety of shapes.

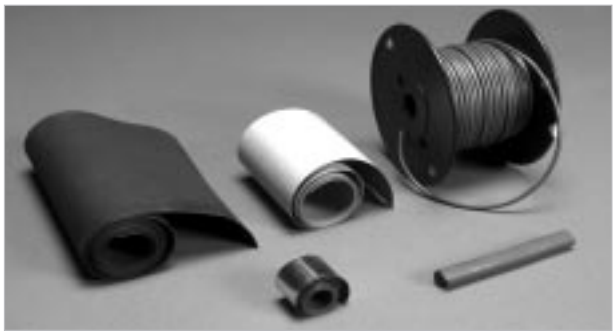
To meet our customers' ever-expanding needs, R&F has developed other magnetically loaded materials, which can be used and applied in different ways.

## THERMOPLASTIC EXTRUDING

Traditional elastomers are thermoset materials. Once the materials go through a curing process they cannot be re-melted or re-formulated. Thermoplastic materials are resins that will melt at a specific temperature and be solid at temperatures below that temperature. The material will continue to become viscous at temperatures above its melt temperature. R&F has used different types of thermoplastic materials and loaded them with different magnetic fillers. These include carbonyl iron powder, iron silicide and ferrites. A twin-screw extruder is used to melt the thermoplastic, mix in the magnetic filler and extrude the loaded compound to a specific shape.

R&F has used polyamide and thermoplastic urethane resins to produce several products including microwave absorbing thermoplastic string, hot-melt glue sticks and thermoplastic tape.

The customer can achieve similar electrical properties in the thermoplastic matrix, as can be seen in elastomeric sheets, but be able to manufacture in roll form instead of sheet form.



Thermoplastic products include microwave absorbing tapes, string and hot-melt glue sticks.

## LIQUID RESIN SYSTEMS

R&F Products loads liquid resin systems with magnetic fillers. Resins used include silicone, urethane, polysulfide and epoxy. Several products are produced from these resins including:

### Doctor Bladed Sheets and Tape

R&F is limited in thickness of compression-molded elastomers to 0.015" (0.4 mm). By pulling a liquid film under a precision blade, magnetic films from 0.002" to 0.020" (0.05 mm to 0.5 mm) in thickness can be produced in lengths up to 144" (3657.6). Both urethane and silicone have been used to make these thin magnetic films.

### Cast Components

R&F can cast absorbers from silicone and urethane loaded liquid compounds. The casting process allows the use of aluminum tooling for lighter weight and lower cost. Sheet material can be cast as well, or the customer can cast their own components by procuring the loaded resin systems.

### Paints

R&F can supply an epoxy- or urethane-loaded resin that can be diluted and sprayed onto a surface with standard spray equipment.

## EXTRUDED ELASTOMERS

R&F Products' parent company, Laird Technologies®, routinely extrudes several geometries of conductive elastomers. R&F uses this capability to extrude tubing, gaskets and other geometries of its magnetically loaded material.



Thermoplastic extruder for microwave absorbing thermoplastic products.

## FORM-IN-PLACE AND MOLD-IN-PLACE

R&F is working with Laird Technologies to provide both form-in-place and mold-in-place absorbers.

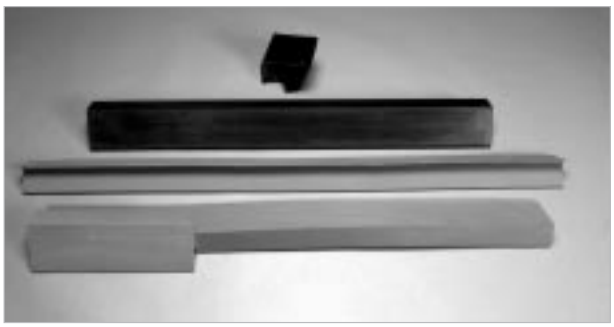
### Form-in-Place

A magnetically loaded paste can be injected in a cavity by an X/Y servo controlled dispensing machine. The paste will fill the cavity and cure in place. This is a way to provide high-frequency shielding for microwave cavities.

### Mold-in-Place

Laird Technologies' injection molding machines will inject standard magnetically loaded rubber compounds into the cavity of a microwave housing using matched metal tooling. The compound will cure in place in the cavity. This will allow highly controlled absorbers to be directly installed without using a "peel and stick" absorber component.

R&F continually works to expand our products and processes to meet your specifications. Please contact an applications specialist at R&F with your specific requirements.



Conformally molded elastomeric components.

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# ANALYSIS, TEST AND PROTOTYPE DEVELOPMENT



Transmission tunnel and microwave test equipment for material property measurement.



Computer controlled network analyzer provides amplitude and phase measurements on microwave absorbers.

R&F Products, combined with Laird Technologies, has an exceptionally strong research and development capability. Staying at the forefront of microwave absorber technology requires the ability to perform accurate measurements of absorber performance and material properties, the ability to perform computer analysis of new absorber designs and, finally, the ability to build and test prototype absorbers and components.

R&F and Laird Technologies® have worked on internal product development programs to combine absorbers with EMI shielding. The projects completed are listed below:

### Board Level Shielding with Absorbers

Increasing usage of printed circuit boards in complex electronics require unique shielding solutions. Laird has developed a near field measurement to accurately determine the effectiveness of board level shielding (BLS). Several of Laird's board level shields have been characterized with this technique. Laird has further investigated the enhancement of performance at greater than 2GHz with the addition of microwave absorber to the BLS. Further work has been done on Flomerics™ FLO-EMC to analytically investigate the performance improvement of BLS using absorbers at high frequency.

### EMI/Air Filters

R&F's reticulated foam has been tested as an air/dust filter for IT applications. The reticulated foam is the same material that is currently used for air intake filtration on routers and other network systems. The absorbing capability of the foam also helps with high-frequency EMI problems faced by design engineers. A thorough analysis of filtration capabilities has been completed, as well as UL94 HF1 flammability testing.

### Absorber/Thermal Materials

R&F has enhanced the thermal conductivity of its magnetic absorbers by the addition of thermally conductive fillers. These fillers do not degrade the microwave absorbing property of the material while enhancing the thermal conductivity for use as a thermal pad.

R&F continues to do a significant amount of military product development for its customer base. Some of these projects include:

### Structural Absorbers

In addition to its product line of structural foams and treated honeycomb core, R&F designs and produces structural composite absorbers. Using resistive films, magnetic layers and different dielectric constant reinforcing layers, R&F can manufacture structures with excellent mechanical properties, broadband electrical properties and good environmental capabilities. R&F is experienced in the electrical and mechanical properties of a variety of reinforcing materials including: Kevlar®, Spectra, E and S glass, graphite and other materials.

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### Millimeter Wave Absorbers

As both military and commercial systems move to higher frequencies, there is a growing need for absorbers that work to 100GHz. R&F has designs for specific resonant frequencies in the millimeter wave band, as well as broadband designs. R&F is working on several military programs at these frequencies, as well as automotive radars and millimeter wave communications programs.

### Resistive Film Development

R&F provides design and fabrication work with frequency selective surfaces (FSS) and resistive films. R&F can spray carbon-based resistive films on a variety of substrates. R&F also silk-screens both resistive and conductive inks on plastic films. R&F can silk-screen continuous films or dots, squares, crosses and other shapes. R&F can provide design services for antenna terminations, FSS or R-films.

R&F Products has excellent design, test and analysis capability for absorber materials. Some of these capabilities are listed below:

### Mu Epsilon Measurement Capabilities

R&F has a network analyzer to make amplitude and phase measurements from 130MHz to 20GHz. R&F also has a reflectivity arch, transmission tunnel and a variety of coaxial, wave-guide and other test equipment to determine the intrinsic electrical properties of absorber materials. This ability has enabled R&F to build a database that customers can use to design new absorbers and analyze their performance in different situations.

### Analytical Software VBROP

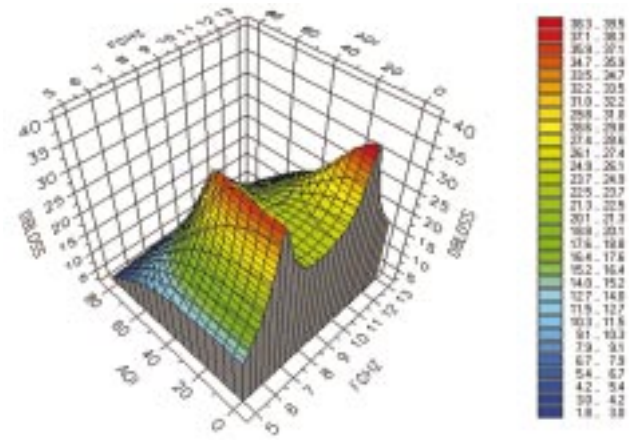
VBROP is a versatile Windows® 95/98/NT-based optimizer of multi-layered stacks for reflection or maximum transmission at specified frequencies, angle of incidence and polarization. The visual basic front-end makes it extremely user friendly, with interactive analysis of layer properties versus performance. It is useful for the design, optimization and detailed performance analysis of RAM, RAS, radomes and microwave windows.

### Analytical Software FLO-EMC

This Flomerics℠ software package allows the user to analyze component, subsystem and system level EMI problems. R&F is working with Flomerics to make its mu epsilon database available to FLO-EMC users. It is possible for designers to put microwave absorbers in their models and understand the effect of microwave absorbers on their system, prior to manufacture. R&F is currently studying board level shielding with absorber inserts using this software.

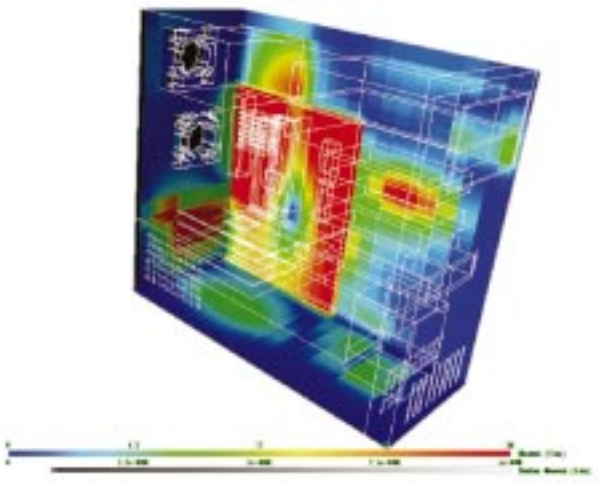
Whether it's prototype development for commercial application, military application or design and analysis needs, R&F can supply valuable engineering assistance to its customers.

FIGURE 1.



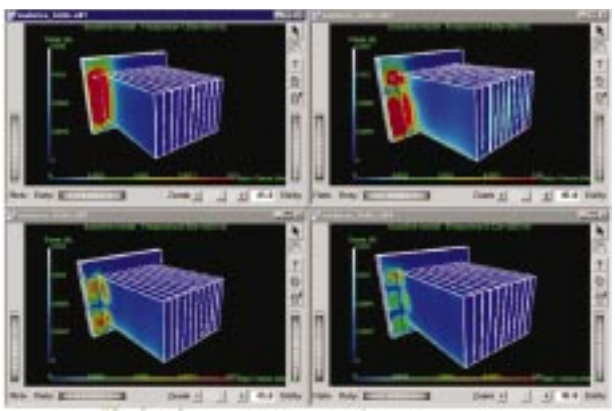
VBROP can optimize absorber performance at various frequencies and angles of incidence.

FIGURE 2.



FLO-EMC can analyze areas of high field intensity for treatment with microwave absorbers.

FIGURE 3.



Unwanted currents on PCBs can be characterized and reduced with microwave absorbers.

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# Effective shielding solutions for a great variety of applications



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