NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA

ELECTRONICS DIVISION TECHNICAL NOTE NO. 125

Title: ECCOFOAM AS A DEWAR WAVEGUIDE VACUUM WINDOW

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ECCOFOAM AS A DEWAR WAVEGUIDE VACUUM WINDOW

Richard F. Bradley and Roger D. Norrod

INTRODUCTION

Emerson and Cuming manufactures a low RF loss, polymer-based foam that we have found to make a good waveguide vacuum window. Eccofoam PS-1.04 is a rigid, closed cell polystyrene material that can be easily machined into desired shapes using standard tooling. The typical compressive strength is 40 psi. Based upon the manufacturer's specifications, the dissipation factor up to 10 GHz is less than 0.0003, comparable to that of teflon, and the dielectric constant is 1.04. Eccofoam PS-1.02 (dielectric constant 1.02) is also available. However, it is not as strong (compressive strength 20 psi) and has a larger cell structure. The material is available in 12" x 36" sheets of 1", 2" or 3" thickness from Emerson and Cuming, Gardena, CA, (213) 321-6650.

LEAK TEST

Helium mass spectrometer leak test on a 1-inch thick sample of Eccofoam PS-1.04 indicates a helium leak rate of 6.4 E-8 cu cm/sec/sq cm. Details of the test procedure appear in EDTN 118. This leak rate is of the same order of magnitude as the best vacuum seal material described in EDTN 118. Helium diffusion time is on the order of 10 minutes for the sample and the leak rate stabilization time is over 30 minutes--longer than any other material tested.

WINDOW CONSTRUCTION

Waveguide windows for use at 1.3-1.8 GHz and 3.0-3.4 GHz were constructed using Eccofoam PS-1.04 as the vacuum seal. The foam is machined to obtain a snug fit inside the waveguide. Foam thickness is determined by the vacuum pressure developed over the waveguide cross-section. A 2.5" thick piece, 6.3" in diameter, is used at 1.3-1.8 GHz and a 1.0" thick piece, 4.1" in diameter, is used at 3.0-3.4 GHz. The foam is mounted inside the waveguide using A-12 epoxy manufactured by Armstrong Products Company, Warsaw, Indiana. An epoxy retaining groove of 0.030" width with a depth of 0.050" is machined into the guide at the midway point of the foam thickness. The aluminum waveguide is roughened using 150 grit sandpaper, and a 50:50 mixture of epoxy is spread on the foam edge and on the inside of the waveguide. The foam is then pressed into place. Note that the epoxy retaining groove may not be necessary in smaller diameter waveguides.

OBSERVATIONS

Improvements in the RF and vacuum performance of this window design were observed in the 3.0-3.4 GHz receiver at Green Bank. The previous window design used 0.030" thick polyethylene and an O-ring as a vacuum seal, with Eccofoam as a rigid support for the polyethylene. The O-ring groove, together with the dielectric, created a large narrow-band resonance in the loss of the waveguide. This window design was replaced with the Eccofoam PS-1.04 and epoxy design. Dewar evacuation time is slightly improved. RF measurements indicate less than 0.01 dB resistive loss through the window, and the polarizer-feed match is improved over the 3.0-3.4 GHz band. The noise temperature of the receiver is improved by 0.5 K. The new window design is used in the 1.3-1.8 GHz VLBA test receiver in Green Bank. Approximately a 0.5 K improvement in the receiver noise has been measured compared with using 0.050" thick polyethylene as the vacuum seal.

SUMMARY

The combination of low RF loss, low dielectric constant, and low leak rate makes this material a good candidate for use in constructing waveguide vacuum windows. Broad-band, well matched windows with negligible noise contribuiton are possible. In addition, the Eccofoam is a relatively good thermal insulator and, hence, eliminates condensation problems on the window. The large volume of the foam window tends to make initial dewar evacuation slightly longer, probably due to water vapor adhering to the foam. The foam is fragile; thus, care must be taken during window assembly and use to prevent accidental chipping or puncture.

RFB/RDN/cjd

Attachment
E&C Data Sheet on
"Dielectric Materials",
Tech. Bul. 6-2-4

DIELECTRIC MATERIALS

Emerson & Cuming

Dewey and Almy Chemical Division
W. R. Grace & Co.
Canton, Massachusetts 02021 U.S.A.
Telephone (617) 828-3300

TECHNICAL BULLETIN 6-2-4

ECCOFOAM® PS

Adjusted Dielectric Constant Plastic

ECCOFOAM PS is a series of low weight, extremely low loss polystyrene based plastic foams of adjusted dielectric constant. It finds use in microwave lens, waveguide and antenna applications. Microwave windows have also been made from ECCOFOAM PS. In the dielectric constant range from 1.02 to 1.1, large blocks of ECCOFOAM PS can be molded. Moldings 8 ft. (2.4m) in diameter and 4 ft. (1.2m) in thickness have been made. ECCOFOAM PS will withstand outdoor exposure but some protection to avoid moisture absorption is advisable, particularly at the lower densities. Maximum use temperature of ECCOFOAM PS is about 75° C (167° F).

The following materials are available:

Dielectric Constant 10^2 to 10^{10} cps	Accuracy of the Dielectric Constant	Dissipation Factor 10^2 to 10^{10} cps	Approximate Specific Weight g/cc	(Lbs/cu. ft.)	Sheet Size cm	(Inches)	Thickness cm	(Inches)	Typical Compressive Strength Kg/cm²	(psi)
*1.02	±0.01	Below 0.0002	0.017	(1.10)	30 x 91	(12 x 36)	2.5, 5.1, 7.5	(1.0, 2.0, 3.0)	1.4	(20)
*1.04	±0.01	" 0.0003	0.035	(2.20)	30 x 91	(12 x 36)	2.5, 5.1, 7.5	(1.0, 2.0, 3.0)	2.8	(40)
*1.06	±0.01	" 0.0003	0.051	(3.20)	30 x 91	(12 x 36)	2.5, 5.1, 7.5	(1.0, 2.0, 3.0)	6.3	(90)
1.1	±0.02	" 0.0004	0.085	(5.30)	46 x 76	(18 x 30)	2.5	(1.0)	9.1	(130)
1.2	±0.02	" 0.0004	0.168	(10.5)	46 x 76	(18 x 30	2.5	(1.0)	21.1	(300)
1.3	±0.02	" 0.0004	0.248	(15.5)	46 x 76	(18 x 30)	2.5	(1.0)	49.2	(700)
1.4	±0.02	" 0.0004	0.328	(20.5)	46 x 76	(18 x 30)	2.5	(1.0)	77.3	(1100)
1.5	±0.02	" 0.0004	0.404	(25.2)	46 x 76	(18 x 30)	2.5	(1.0)	91.4	(1300)
1.6	±0.02	" 0.0004	0.481	(30.0)	46 x 76	(18 x 30)	2.5	(1.0)	112.5	(1600)
1.7	±0.02	" 0.0004	0.553	(34.5)	46 x 76	(18 x 30)	2.5	(1.0)	140.6	(2000)
1.8	±0.02	" 0.0004	0.625	(39.0)	46 x 76	(18 x 30)	2.5	(1.0)	175.8	(2500)
1.9	±0.02	" 0.0004	0.694	(43.3)	46 x 76	(18 x 30)	2.5	(1.0)	210.9	(3000)

Discontinued Aug 83

* Can be supplied in larger size sheets or in fire retardant form on special order.

Intermediate dielectric constants in the range of 1.0 to 2.0 can be made on special order. The material can be molded to order to special sizes and shapes. For example, a complete lens several feet in dimension can be molded to exact size. An artificial dielectric, ECCOFOAM PS-A (Technical Bulletin 6-2-4A), is also available. It is lower in density than ECCOFOAM PS for dielectric constants above 1.1.

This information, while believed to be completely reliable, is not to be taken as warranty for which we assume legal responsibility nor as permission or recommendation to practice any patented invention without license. It is offered for consideration, investigation, and verification.

NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA

ELECTRONICS DIVISION TECHNICAL NOTE NO. 131

Title: MOISTURE ABSORPTION BY ECCOFOAM DIELECTRIC MATERIAL: ADDENDUM TO EDTN #125

Author(s): Richard F. Bradley

Date: April 30, 1985

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MOISTURE ABSORPTION BY ECCOFOAM DIELECTRIC MATERIAL

ADDENUM TO EDTN #125

Richard F. Bradley

A recent test of the new 2.9-3.4 GHz receiver which incorporates the Eccofoam window design described in EDTN #125 revealed a slow drift of approximately 10 degrees in the receiver noise temperature while the receiver was exposed to environmental conditions on the 300-ft telescope in Green Bank. This increase in noise temperature was traced to moisture absorption by the Eccofoam material.

To correct this problem, a single sheet of household plastic wrap is placed over the exposed Eccofoam surface. The noise added by the plastic wrap itself could not be measured. The receiver was then installed on the 140-ft telescope, and tests reveal no noise temperature drift. Therefore, as advised by the manufacturer in Emerson and Cuming Technical Bulletin #6-2-4, it is crucial that a thin moisture seal be used over the exposed end of the waveguide window.