DESIGN OF TEMPERATURE CALIBRATION LOADS AND IMPEDANCE MATCHING TO FREE SPACE

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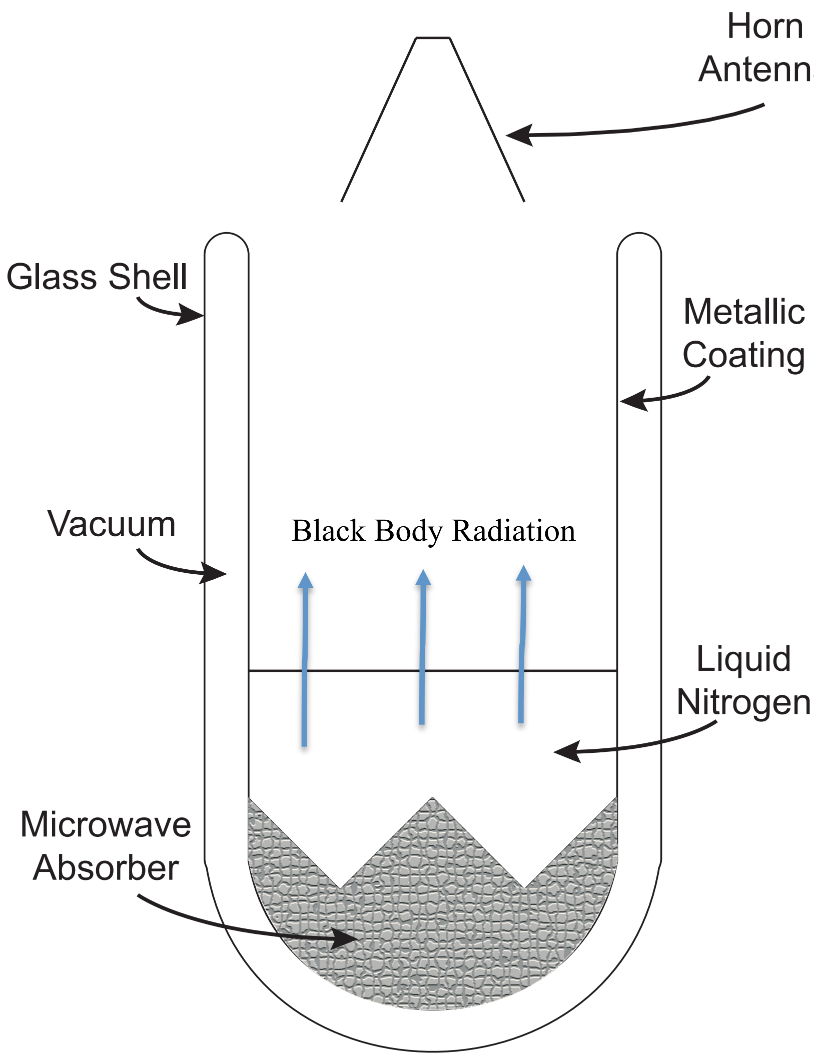
CALIBRATION SOURCES AT AMBIENT AND LIQUID NITROGEN TEMPERATURES

- Need two blackbody radiation sources that can couple to a microwave receiving antenna.
- The two sources must have exactly known temperatures.
- Liquid nitrogen (LN2) slowly boils in the Dewar flask to maintain its temperature at the boiling point of 77 K
- The microwave absorbing material in the LN2 liquid radiates as a black body.
- The black body source has a pyramidal surface to avoid plane wave reflections at the surface.
- Some experimenters use a large open sheet of pyramidal absorber for the ambient temperature source.
- Some use absorbing material in a metal cylinder of similar dimensions to the LN2 source.
- Ambient temperature is measured with a thermometer inside the absorber material.

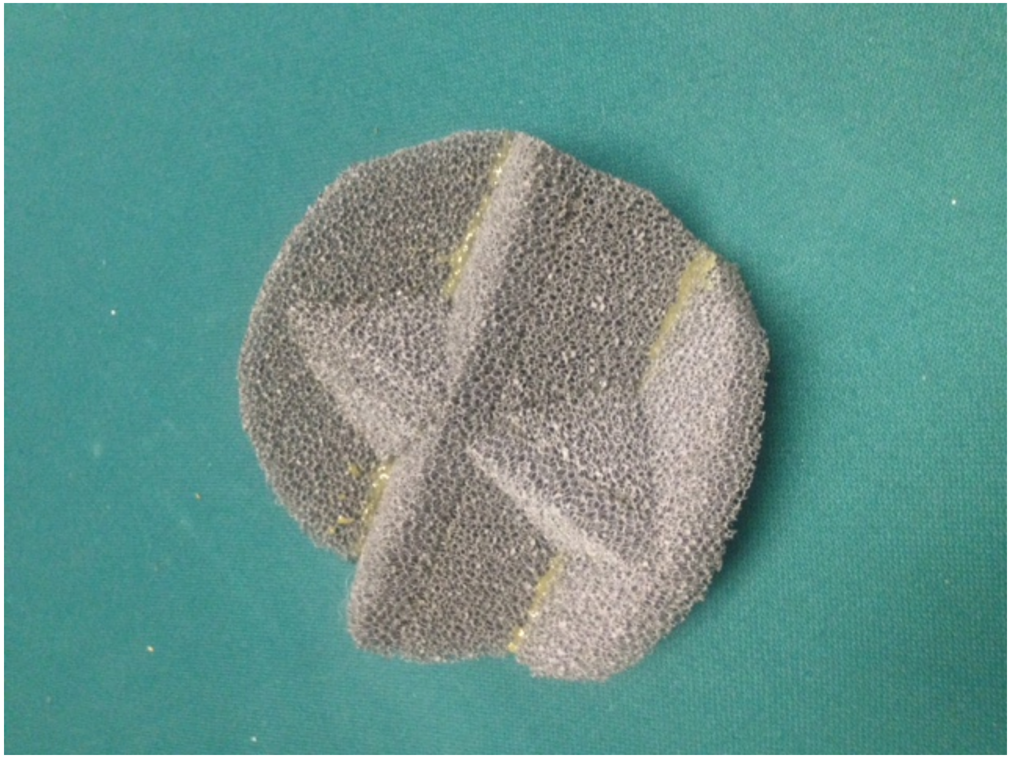
LIQUID NITROGEN TEMPERATURE CALIBRATION



- Dewar Flask acts as a waveguide
- Boiling liquid nitrogen (LN2) @ 77 K
- Absorber acts as 77K black body
- Bensadoun et al. used numerous mylar and fiberglass windows to prevent condensation and control IR radiation into the dewar.
- I have found that you can do without windows for short measurement runs lasting less than 30 minutes.
- Boiling LN2 gives off absolutely dry nitrogen gas keeping moisture out.

This design was adapted from an article by Bensadoun et al. (1992) Smoot group

HOME MADE ABSORBER SURFACE



- Absorber material must have a pyramidal surface otherwise you get reflections leading to cavity resonances in the Dewar Flask.
- I have made a pyramidal surface using ½” flat absorber sheet glued with superglue.
- This configuration works well in the tests described here.

Pyramidal microwave absorber material is available from numerous sources. Cuming sells their materials on their website, www.cuming.com

CUMING MICROWAVE

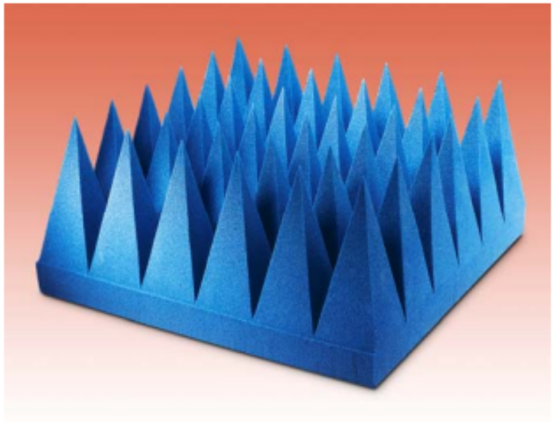
Technical Bulletin 390-1A

C-RAM SFC-HP

VERY HIGH PERFORMANCE BROADBANDED PYRAMIDAL RF ABSORBER

RoHS Compliant

C-RAM SFC-HP is a series of very high performance broadbanded RF absorbers made from specially treated low density polyurethane foam. The product is flexible and tolerant of physical abuse. Using a very steep pyramid design which provides an impedance gradient, C-RAM SFC-HP provides improved premium performance in anechoic chambers at both normal and off-normal incidence angles. These products meet all of the fire retardancy requirements of NRL Specification 8093 tests 1, 2, and 3, MS-8-21 tests 1, 2, and 3, and T.I. drawing 2693066, as well as ASTM E-84-97a, Class A.



TYPICAL PROPERTIES

Typical weights, dimensions, and reflectivities of the various grades of C-RAM SFC-HP are given in the tables on the reverse side.

Typically, C-RAM SFC-HP absorbers can handle up to 1.0 W/in^2 (1.5 kW/m^2) of RF energy in a temperature controlled room, but this is dependent upon frequency and application.

The product is black throughout, and generally is sprayed with a light blue surface coating, both for cleanliness and to provide better light reflection inside a chamber. The absorber can be left unpainted if requested.

AVAILABILITY

Standard sizes of C-RAM SFC-HP are listed in Table 1, ranging from 8 to 36 inch height. Are shaped as conventional pyramids and supplied as square 24 inch (610 mm) panels.

In addition to simply supplying a bill of materials, Cuming Microwave designs and installs complete anechoic chambers. Chambers can be designed to meet your specifications, and an entire kit of materials is supplied, including factory pre-cuts of special fitting parts. We can install all materials or supply technical support to help you complete your own installation.

IMPEDENCE MATCH OF CALIBRATION SOURCES AND SPACE

- An issue arises with the process of using two calibration sources and a deep space background measurement
- All three must have same impedance match to the detector
- A result of the mismatch is standing waves in the waveguide
- Of course there are no reflections when pointed at the sky
- These effects can introduce errors.
- Two principle effects
  - Preamplifier gain is sensitive to the impedance match. Must be the same for each condition.
  - Standing wave patterns make it difficult to reposition the antenna

IMPEDANCE MATCH TESTS

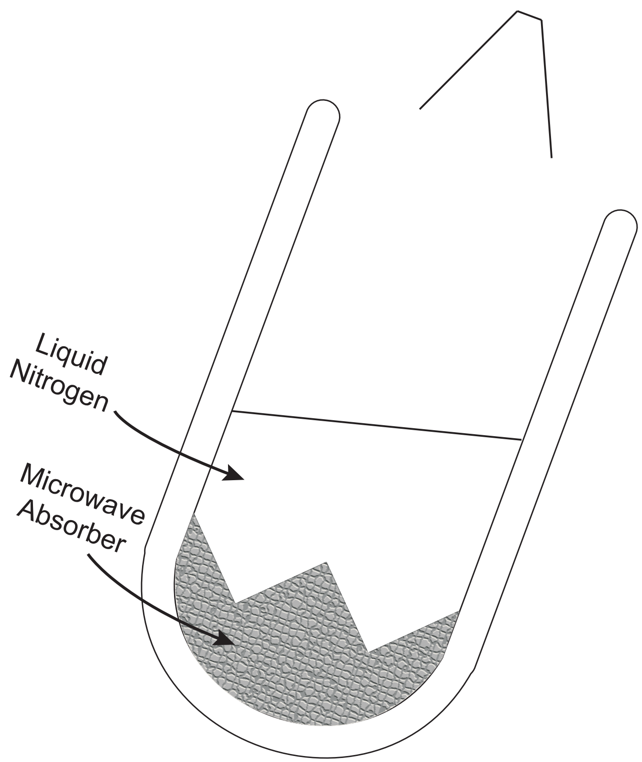
- Tested two different configurations
  - LNB from Dish Network antenna
  - Kuhne electronics 10.3 GHz preamp and transverter

  Standing waves occur only in LN2 filled dewar.

  Due to plane wave reflections from the air-LN2 surface

  LN2 has an index of refraction of 1.2 at 10 GHz
- The Kuhne system had weaker reflections than the dish network system
- For dish network horn It was possible to eliminate reflections by tilting Dewar flask

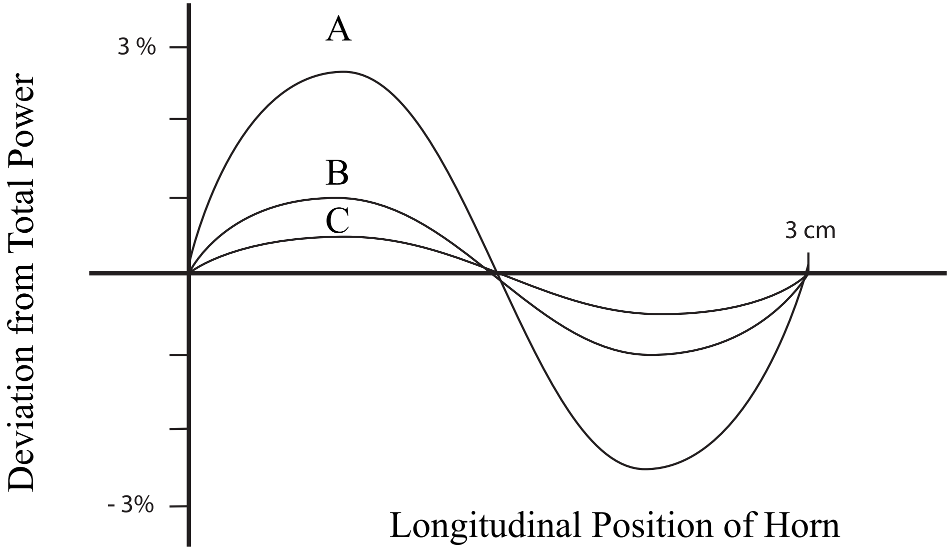
TILTED COLD LOAD DEWAR



- Tilting the dewar changes the angle of the interface and substantially reduces the formation of standing waves.

INTERFACE INTERFERENCE

Interference causes peaks and valleys as you move horn antenna longitudinally.



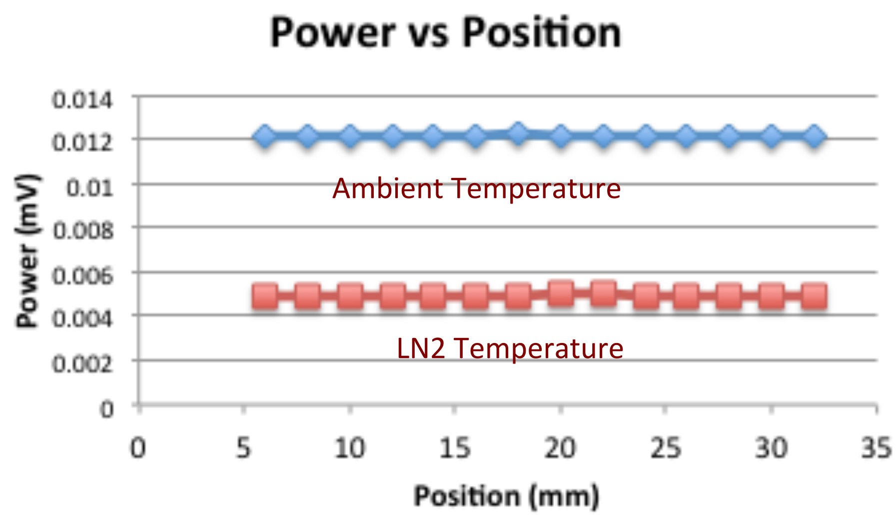
- Reflection is reduced by
  - Tilting LN2 interface
  - Using the proper polarization orientation
  - This only works with microwaves of a single polarization

A – Axis of antenna normal to LN2 surface
B – LN2 surface tilted at 20 degrees
C – Tilted 20 degrees and polarization in the plane of incidence as in Brewster's angle.

Brewster's angle = 32 degrees. May be difficult to tilt Dewar that far. The 0.5% peaks at 20 degrees of tilt are barely detectable on the analog meter. This procedure substantially improves the reproducibility of the cold load calibration.

COMMERCIAL PREAMPLIFIER PERFORMANCE

- Kuhne MKU 102 S EME preamp and 10 MKU G4 transverter at 10.3 GHz input
- Mounted antenna on sliding table with digital position gauge
- Measured noise vs longitudinal position
- There are no standing waves at ambient or LN2 temperature
- This means that there is the same match as free space



No need to tilt Dewar with this configuration