DEVELOPMENT AND CAPABILITIES OF SPECIAL ABSORBERS FOR HIGH-POWER APPLICATIONS

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ABSTRACT

This paper describes the power handling tests on a selection of Emerson & Cumings Microwave Products pyramidal high power absorbers. Especially the latest developed high power absorber ECCOSORB HFX-HC is discussed. The hollow concept of this absorber as well as the open-cell structure and high temperature resistance of the absorber panels result in an optimal power handling capability. Steady state temperatures without and with additional ventilation were studied.

1. Introduction

When dealing with high power densities in anechoic chambers, specially designed types of absorbers are needed. Absorbers in high power applications should be able to handle the large amount of heat generated by the absorption process.

The high power absorbers are installed in a limited area in the focal plane of the antenna in order to dissipate the energy in the high intensity region of the diffraction pattern.

Emerson & Cuming Microwave Products supplies several types of high power absorbers with ECCOSORB HFX-HC being the premium type.
This paper will focus on ECCOSORB HFX-HC and briefly describe the other types.
The power handling capabilities as specified in our technical literature are with natural convection. A higher air flow by additional ventilation will obviously increase the power handling capability. Both situations will be discussed for ECCOSORB HFX-HC.

2. Test Set-up

As real RF conditions cannot be compared with high temperature conditions in e.g. oven heating or even in flammability tests, specific tests are needed to define the acceptable power densities.

High power tests were carried out at Thales, Hengelo, The Netherlands.

The power densities were generated by decoupling a certain fraction of EM power from a high power emitter (X-band) and by leading this signal by means of a waveguide to a small horn antenna, from which the absorber material was radiated. The test layout is shown in figure 1.

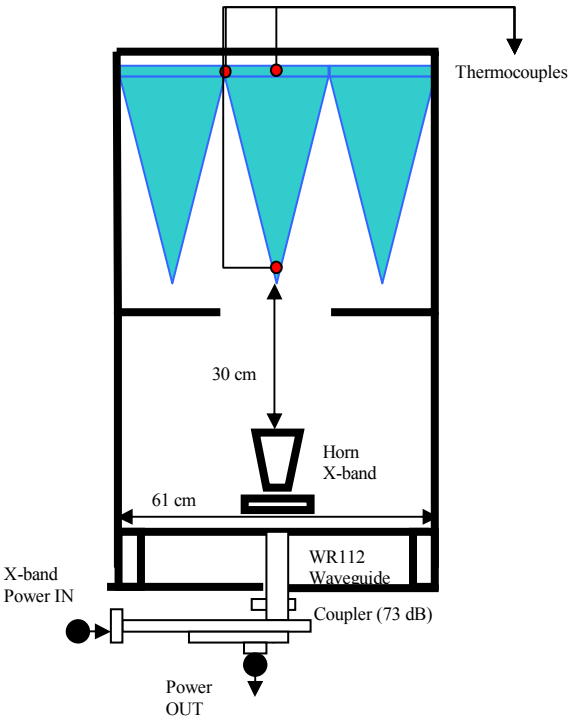

Figure 1: Test Set-up
ECCOSORB HFX-HC-18-NRL

In order to vary the input power density, the power from the emitter was controlled electronically. After the determination of the attenuation of the emitted power caused by the coupler (73dB), the peak power of the signal emitted by the horn antenna could be measured. The average power could subsequently be determined from the duty cycle, which is defined as the ratio of the peak

width (5.3 μs) and the repeat time (150μs) of the generated EM signal (3.5%).
A distance of 30cm between the horn antenna and the upper absorber surface (absorber tip) ensured that the whole of the absorber was in the farfield zone of the horn.
The power density radiating the absorber tips could subsequently be calculated with the following equation:

$$p = \frac{P_t G_t}{4\pi R^2}$$

P_t : Measured transmitted power
G_t : gain of the transmit antenna (14,8 dB at 9.4 GHz)
R : distance from horn to absorber tip (30 cm)

For safety reasons, the tests needed to be performed outdoors. To protect the absorber from weather conditions such as wind and rain, which could cause favourable cooling effects, the absorbers were placed in a box. Such configuration however impedes the natural convection heat transfer mechanism as the air is confined in the box. It is therefore believed that these test conditions were more severe compared to the situation in an anechoic chamber. The obtained results are considered to be on the conservative side.

3. Test procedure

When the ECCOSORB HFX-HC absorber was exposed to different power densities, the absorber tip reached the highest temperature in all cases.
Therefore the physical and thermal behaviour of the latter was chosen to judge the power handling capabilities of the absorber material.

The maximum power handling capability is defined as the power level at which the steady state temperature equals the maximum allowable temperature for the absorber material (i.e. no physical deterioration).

4. Test results ECCOSORB HFX-HC

ECCOSORB HFX-HC is a series of hollow pyramidal absorbers made of lossy honeycomb material. The honeycomb material is selected for its high temperature resistance, well above the values for foam and standard honeycomb materials. The material resists temperatures up to 210°C.
The open structure of the honeycomb material as well as the hollow design of the absorber allow an optimal airflow through the absorber material. A detail of the absorber structure is given in Figure 2.

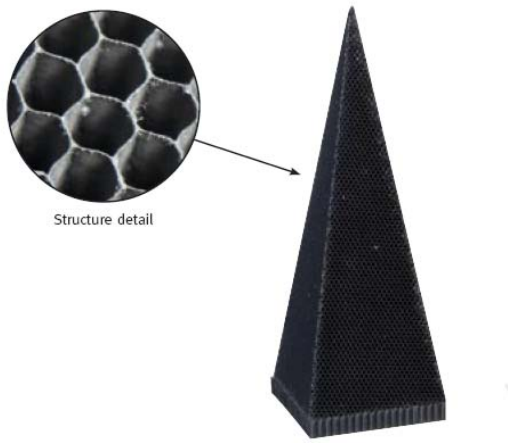

Figure 2: Single ECCOSORB HFX-HC Pyramid with structure detail

4.1 Power handling capability without additional ventilation

Steady state temperatures were monitored at different power levels for ECCOSORB HFX-18-HC.
The equilibrium temperature was typically reached after 10 to 15 minutes.
Aside from the specified maximum allowable temperature for the honeycomb material (210°C), the absence of physical deterioration was verified to define the maximum power level.
Figure 3 shows the relation between power density and the temperature in the absorber tip.

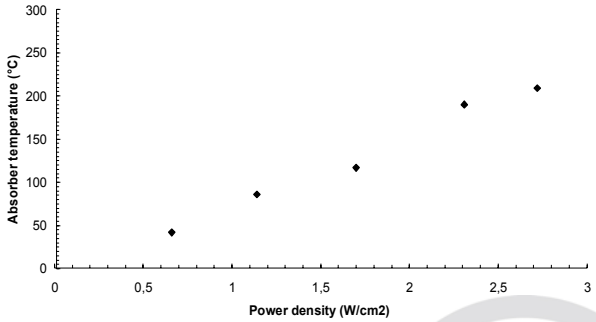

Figure 3: Equilibrium temperatures as function of power density for ECCOSORB HFX-18-HC

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While even at a power level of 2.7 W/cm² the physical damage of the absorber was found to be minimal, the absorber is specified to withstand at least 1.5 W/cm².

4.2 Power handling with additional ventilation

As discussed in 3.1, ECCOSORB HFX-HC can withstand at least 1.5 W/cm² with unimpeded airflow. Higher power levels or lower maximum absorber temperatures can be reached when additional cooling systems are applied.

The data discussed here refer to a test program on ECCOSORB HFX-36-HC where the required cooling capacity was studied, needed to obtain a maximum absorber temperature of 60°C during a continuous RF flux of 3.0 W/cm².

The specific trigger to maintain the absorber temperature at such low level was a safety measure where the customer wanted to avoid injuries when touching the absorber. While 60°C is far below the maximum allowable absorber temperature, the experiments present valuable information on the relationship between power handling capability and additional cooling.

The relationship between air velocity and tip temperature is given in Figure 4.

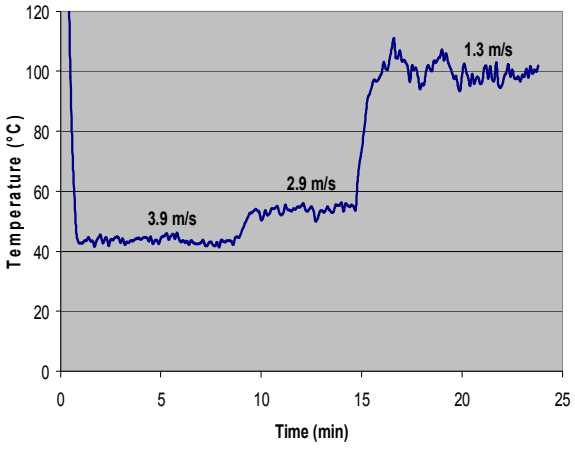

Figure 4: Absorber tip temperature with different air velocities (power level 3.0 W/cm²)

An air velocity of 2.9 m/s resulted in a steady state temperature of 54°C which meets the objective.

Although the available data is limited, the correlation between the temperature in the absorber tip and the cooling air velocity can be represented as shown in Figure 5.

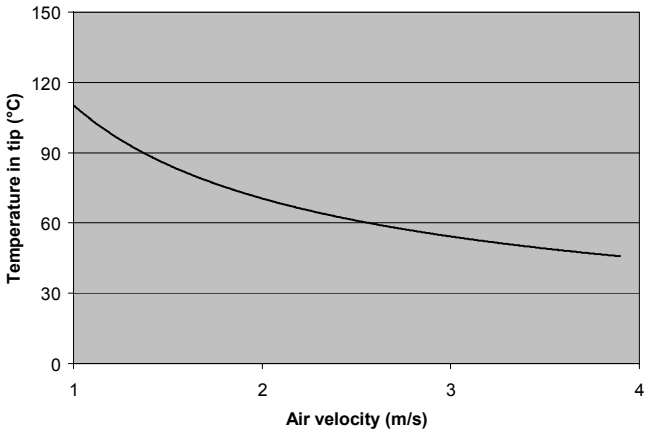

Figure 5: Absorber tip temperature with different air velocities (power level 3.0 W/cm²)

5. Emerson & Cuming Microwave Products' range of high power absorber

Aside from ECCOSORB HFX-HC, Emerson & Cuming Microwave Products supplies other high power absorbers, each with their own power level capability. A brief description of 2 types of high power absorbers is included below: ECCOSORB –SPY-NRL and ECCOSORB HPY-VH-NRL

ECCOSORB SPY-NRL is made of an open cell foam with large cell size. The open structure favors air circulation which enhances the power handling of the absorber. The power handling capability of the ECCOSORB SPY-NRL is specified at 0.8 W/cm², about 5 times higher compared to the standard pyramidal foam absorber ECCOSORB VHP-NRL

ECCOSORB HPY-VH-NRL is a hollow pyramidal foam absorber with ventilation holes, again allowing extra cooling at high power levels.

Figure 6 shows the temperature of the absorber tip at a power level of 0,25 W/cm². It was shown in the test, as can be expected for a hollow absorber, that the highest temperature was measured at the absorber tip. The steady state temperature was reached after 30 minutes.

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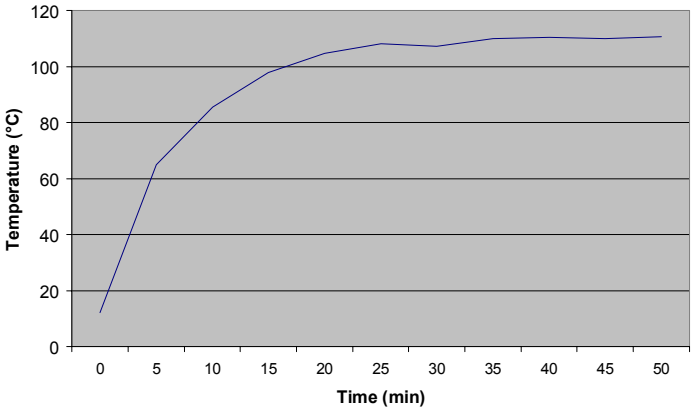

Figure 6: Temperature absorber tip of ECCOSORB HPY-50-VH-NRL (Power level 0,25 W/cm²)

6. Conclusion

The power handling capability of ECCOSORB HFX-HC was studied in this paper. The hollow concept of the absorber as well as the used honeycomb material resulted in a power handling capability of 1,5 W/cm². To further increase the power handling capabilty, additional cooling can be applied. The steady state temperature with a power level of 3 W/cm² and an air velocity of 1,3 m/s was 100°C, far below the allowable absorber temperature.

Two other types of high power were discussed, ECCOSORB HPY-VH-NRL and ECCOSORB SPY-NRL. Respective power handling capabilities are 0,3 W/cm² and 0,,8 W/cm².

All these results refer to the specific test set-up used. The heat transfer mechanism in the test box was unfavourable compared to the reality in an anechoic chamber. It's therefore believed that the given power handling values are on the conservative side.

7. References

(1) M. Hagenbeek, "High power testing of broadband absorbers" SEWACO, Royal Netherlands Navy, The Netherlands, 1999

(2) J. Schryers, "Power handling capability of Emerson & Cuming's ECCOSORB HFX-HC and ECCOSORB SPY High Power Absorbers". Tech. Rep.02_14 , Emerson & Cuming Microwave Products NV, 2000

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