

OVERHEAD CANOPY DESIGN



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In dB
Volume 1,
Issue 5, we
examined
the near
field
response of
an array of
plane panels
1 m in
width and
spaced by

1.25 m. The scattered pressure is uneven with minima where the geometric reflection point for a receiver is between panels, and maxima where the geometric reflection point lies on the panels. Due to these absences between reflectors at high frequency, and the strong specular reflections between, it would be normal to use shaped elements, such as arcs, instead of plane panels to scatter energy more evenly to all receivers. However, shape alone will not guarantee uniform coverage. As we will see it is a combination of shape and arraying. Let's look at the effect of using a periodic array of semicylinders, as is customarily done.

A single cylinder is an efficient disperser of sound in one plane, and a single sphere is efficient at dispersing hemispherically. They generate responses that mimic the behavior of radiating line and point sources, respectively. Figure 1 shows the scattering from a semicylinder as a function of frequency. The radial axis range of this graph is only 20 dB, so at all frequencies, the response from the semicylinder is fairly omnidirectional. The 400 Hz line is where the wavelength is roughly the width of the semicylinder, and so some finite width diffraction lobing effects are seen. The lowest frequency, 40Hz, is not omnidirectional, because the rear of the semicylinder becomes important - it would be

omnidirectional if a full cylinder had been modeled. At the two highest frequencies, the scattered level only varies by 2-3dB over the receiver arc.

It might appear that the cylinder is the ideal diffuser - the Holy Grail of diffuser design - but this unfortunately is not the case. A single cylinder on its own is rarely of much use. The example given in Figure 1 is 0.5m deep, already deeper than many architects allow, and it was only 1m wide, not wide enough for most applications. One solution is to use multiple semicylinders in an array. Then the response of the semicylinder array is dominated by how the semicylinders are arranged, and the perfect response from a single semicylinder becomes a secondary and less important issue.

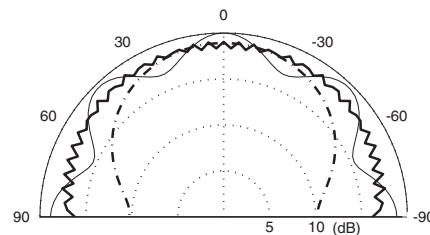


Figure 1. Scattering from a 1 m diameter semicylinder for various frequencies.

- 40 Hz ($l = 8.5d$, $d = \text{cylinder diameter}$)
- 400 Hz ($l = 0.85d$)
- 4000 Hz ($l = 0.085d$)

It would be convenient if we could describe a method to mathematically evaluate the uniformity or diffuseness of the polar responses at each frequency. In this way, we could generate a plot of the diffusion coefficient versus frequency, in a similar way in which we illustrate the magnitude response of a loudspeaker or microphone. Fortunately, many years of research have been devoted to this problem and the diffusion coefficient has been developed and described in AES-4id-2001 information document and also in the book "Acoustic Absorbers and Diffusers:

Theory, Design and Application" by Trevor J. Cox and Peter D'Antonio (Spon Press 2004). The diffusion coefficient is obtained from the circular autocorrelation of the 1/3-octave polar responses. Using this diffusion coefficient, we can now compare the uniformity of scattering of an array of semicylinders 0.61 m wide with a radius of 0.3 m. In Figure 2, we show the random incidence diffusion coefficients for 1, 2, 4, 6 and 12 periods. It is apparent that the uniform scattering illustrated in Figure 1 for 1 semicylinder and duplicated

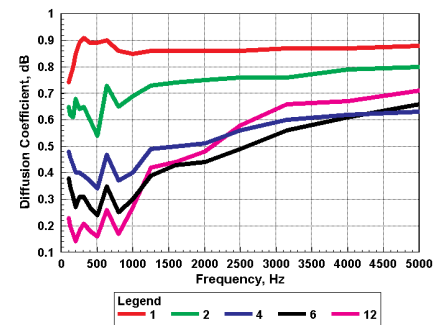


Figure 2. Diffusion coefficients for 1, 2, 4, 6 and 12 semicylinders. The semicylinders are 0.61 m wide with a radius of 0.3 m. Note the ideal diffusion coefficient for 1 semicylinder, indicated by the polar responses in Figure 1, is systematically degraded due to periodic lobing effects.

in the diffusion response for 1 period in Figure 2, is systematically degraded as the semicylinder is repeated in an array of 2, 4, 6 and 12 units. This is due to lobing in the polar responses caused by periodicity effects and results in non-uniform scattering. So we have seen how the uniform scattering of a single surface is compromised by periodic arraying. It is clear that the design of an optimal overhead canopy array, for the musicians on stage and the audience as well, must minimize the near field specularly minima and maxima as well as the far field periodic lobing effects. We will now describe how to do this, using shape optimization and optimal binary sequence modulation.

