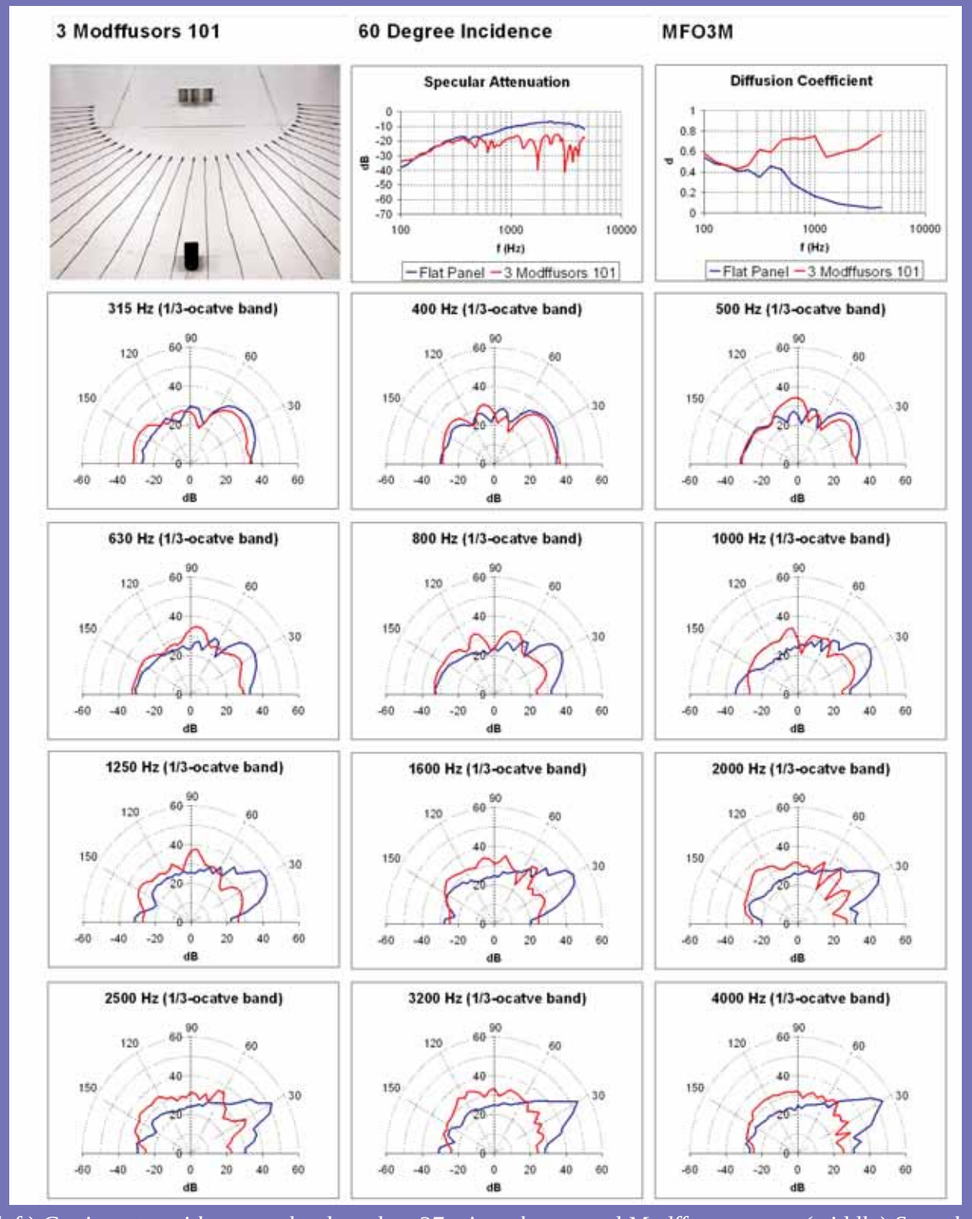
Complete Specification of a Diffusor



Top line: (left) Goniometer with source loudspeaker, 37 microphones and Modffusor array, (middle) Specular Attenuation comparison between a flat panel (blue) and the Modffusor (red) and (right) comparison of the Diffusion (d) Coefficient for the Modffusor (blue) and flat panel (black). The following 12 plots are the third-octave polar responses of the Modffusor (red) contrasted with a flat panel of equal width (blue). Note how uniform the Modffusor diffusion is compared to the specular scattering.

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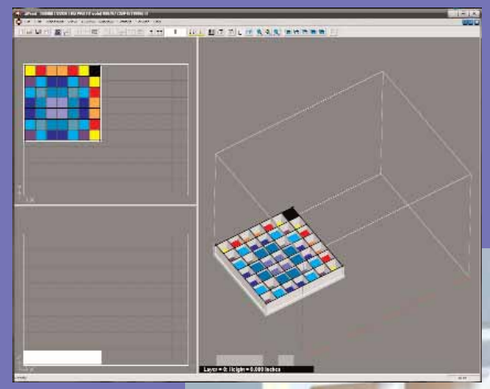
Rapid Prototyping



Concept Modeling and Testing

quick and accurate acoustical evaluation of scattering surfaces

Shape Evaluation

In classical architecture, statuary, relief ornamentation, columns, and other ornamental decoration were both vernacular to the architectural style of the day, but these surfaces also provided useful sound scattering, as is evidenced in many world class concert halls.

What types of surfaces complement contemporary architecture and provide quantifiable sound diffusion?

Two things are needed to answer this question. First, we need a measurement technique and acoustical metric to quantify the uniformity of scattering and second, we need a technique to fabricate scale models of aesthetically desirable surfaces for testing.

The good news is both techniques are now available and RPG is currently using this capability to provide proof-of-performance testing for all of its products.

Rapid Prototyping

Rapid prototyping is the speedy fabrication of sample parts for demonstration, evaluation, or testing. It typically utilizes advanced layer manufacturing technologies that can quickly generate complex three-dimensional objects directly from computer-based models devised by Computer Aided Design (CAD). The computer representation is sliced into two-dimensional layers, whose descriptions are sent to the fabri-

Figure 1. State of the art Rapid Prototyping 3D printer.

Figure 2. 1:5 Scale models. Top left: Golden Pyramid, Top right: Modffusor, Bottom left: Skyline, Bottom right: Omniffusor

cation equipment, Figure 1, to build the part layer by layer. High performance engineered, composite plaster material is used to make strong, high-definition samples that maximize surface finish, feature resolution, and part strength.

In Figure 2 we show 1:5 scale models for RPG's Golden Pyramid, Modffusor, Omniffusor and Skyline (A quarter coin is shown for scaling).

Diffusion Coefficient

RPG developed the Diffusion Coefficient (AES-4id-2001, JAES, Vol. 9 (3), March 2001) to evaluate the uniformity of sound scattering. In Figure 3 (top center), we show a modulated array of three of RPG's latest modulated and optimized diffusors, called the Modffusor, positioned in the 1:5

Figure 3. RPG 2D boundary plane goniometer. Impulse responses at 5 degree increments backscattered from the sample, located at the origin of the microphone and speaker semicircles, are automatically measured under computer control.

scale Diffusion Goniometer. At a given angle of incidence, 37 impulse responses are collected at 5 degree increments and processed into the Specular Attenuation, Diffusion (d) and Correlation Scattering (s) coefficients (top line) and the (12) third octave angular responses (shown on the back page). Figure 4 is an illustration of how the diffusion coefficient is determined from the 37 impulse responses collected for an angle of incidence of 60 degrees. Figure 5, shows the Diffusion and Correlation Scattering coefficients. When evaluating potential diffusors one

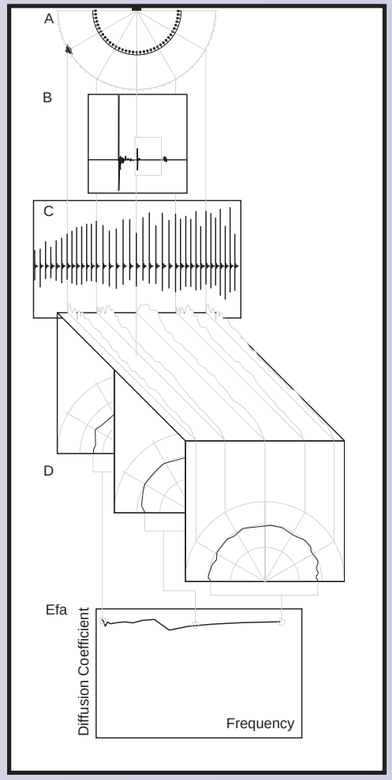


Figure 4. Summary of the data processing technique used to isolate the impulse response at each observation angle, Fourier transform these impulses into the frequency domain, calculate 1/3-octave polar responses and then determine the diffusion coefficient from the autocorrelation of these 1/3-octave polar responses according to AES-4id-2001.

should use the Diffusion Coefficient. The Scattering Coefficient is only useful as a parameter in room modeling programs. For a more thorough discussion of coefficients, please refer to Acoustic Absorbers and Diffusers: Theory, Design and Application, T.J.Cox and P. D'Antonio, Spon Press (2004) on Amazon.

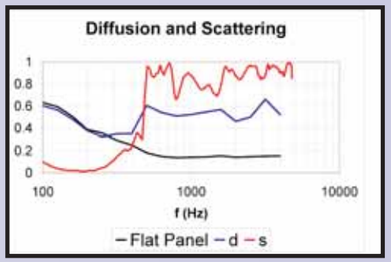


Figure 5. The Diffusion Coefficient (d) for a Modffusor (blue) and a flat panel (black) are compared. The Correlation Scattering Coefficient (s) for 55 degree incidence (approximating random incidence) is also shown in red. The point of departure between the diffusion response for the flat panel and the Modffusor at 300 Hz is the lower frequency limit of the device. The ideal diffusion and scattering coefficients is 1.

Scattering Coefficient

ISO 17497-1 provides a standard measurement method to determine the random incidence scattering coefficient to be used in geometric computer modeling programs. The scattering coefficient, s, is the the proportion of energy not reflected in a specular manner. This definition takes no account of how the scattered energy is distributed, as this is the task of the diffusion coefficient, d, as described. The technique requires the measurement of four reverberation times according to ISO 354, at any scale, with and without the sample present on a stationary and rotating turntable, Figure 6. Four 1:10 scale samples are shown in Figure 7. Figure 8 shows an example of the scattering coefficient obtained by this method for the RPG Skyline.

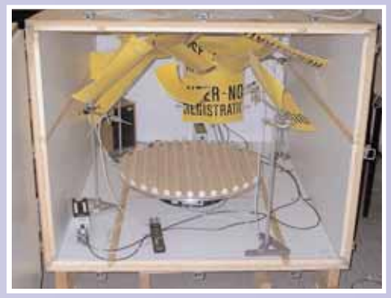


Figure 6. 1:5 scaled reverberation chamber at the Technical University of Denmark used to measure the scattering coefficient as per ISO 17497-1. Photo Courtesy Professor. Jens Holger Rindel

Figure 7. 1:10 scale 300 mm circular model samples of the Waveform 8" Bicubic (top left), Waveform 4" Bicubic (top right), Skyline (lower right) and Modffusor (lower left).

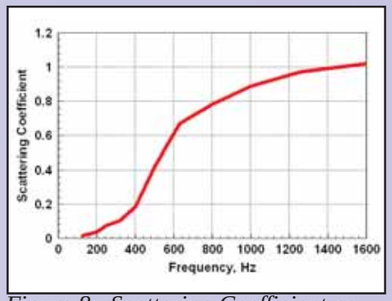


Figure 8. Scattering Coefficient as per ISO 17497-1 for the RPG Skyline