ACOUSTOLOGY 04/2004

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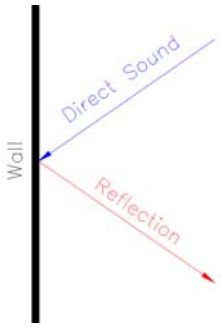
This month: *Pontifications on Diffusion*

Theory and Background

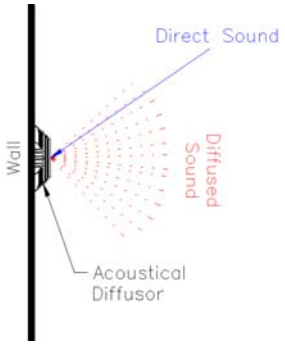
Diffusion is one of the most difficult acoustical concepts to, er, absorb? (Please try and refrain from throwing e-fruit.) Absorption, by contrast, is easy enough – sound gets "soaked up" by absorbers much like a sponge soaks up water. For the purposes of understanding better, let's go through some of the popular lay descriptions of diffusion:

Diffusion is the opposite of absorption. This statement is not really correct. The opposite of absorption is reflection. Indeed, one way to measure absorption is to figure out how much sound is not reflected from a surface. So we can rule this one out.

Diffusion is the scattering (or shattering) of sound. We actually use this description a lot. This probably sums up diffusion best. When sound strikes a flat, hard surface, much of the high frequency sound (and perhaps some mids and lows, depending on the physical size – width and height) is reflected such the *Snell's Law* is obeyed. *Snell's Law*? You might remember that one from your high school physics classes – the angle of incidence equals the angle of reflection. Like this:



Sound above certain frequencies will obey this law when it strikes a hard, flat boundary. A diffusor still provides a surface that will yield results according to *Snell's Law* at certain frequencies. However, since the surface is no longer flat and hard but rough, or textured and hard, the resulting directions of the reflected frequencies will be quite varied. Like this:



So what about phrases like: *Optimum diffusion is obtained when the scattering surface is mathematically optimized over the frequency range of interest*? This is a tough one. There is a lot of research that is ongoing in this regard. Before about 30 or so years ago, diffusion was simply obtained through the use of items like decorative trim, wall and ceiling décor, curved panels, perforated panels, or any other textured, hard surface. And it worked. Many of the "best sounding" halls in the world have great diffusion thanks to creative architecture.

Then along came some great research from Manfred Schroeder, widely considered to be the father of modern acoustical diffusion. Through work with radio wave scattering, Dr. Schroeder discovered that the same concepts using in technologies such as radar jamming could also be applied to concert hall acoustics. Enter the "quadratic residue," "primitive root" and "binary amplitude" diffusion concepts, among others. Commercial acoustical diffusors were born and the industry has been growing ever since.

The catch is many acoustical professionals are not convinced that these types of surfaces are, in fact, optimum. In particular, large convex surfaces and completely random surfaces have shown to provide excellent diffusion – even when compared side by side with more "technical" devices. So the whole concept of "optimum" diffusion is still very much debatable.

How to Use Diffusors

Having established that diffusion is, in fact a good thing – sound is scattered at random to produce an enveloping sound, free of direct reflections that could arrive at a listeners ears as echoes or causing comb filter effects – the question then became along the lines of "how is diffusion used in small rooms, like studios?" The answer – early on – was the *Live-End/Dead-End*™ or *LEDE*™ concept of control room design developed and documented by Chips and Don Davis (no relation). This concept created a dead area in the front of the room around a mix position and a live area around the back of the room, which would otherwise have been a source of detrimental late reflections. This concept is still very much alive today, but is debated much more than was the case 20 or so years ago. (Largely because average studio rooms are getting smaller, where *LEDE* is less appropriate.)

A development from *LEDE* is the *Reflection Free Zone*™, or *RFZ*™. This is the design of choice for many professional, commercial control rooms today. The basic idea is – through the use of angled surfaces, absorption and diffusion – a zone is created around the mix area that is free of any direct reflections from walls, ceilings, floor, etc. A perfect *RFZ* is very difficult to achieve. But it is not impossible. Many rooms have even incorporated diffusion in seemingly unusual locations to enhance the *RFZ* experience.

For most of us, though, the *RFZ* is not quite as obtainable. The typical bedroom or basement studio is simply too small to incorporate a full *LEDE* or *RFZ* design. Therefore, how relevant is diffusion? Here are some rules of thumb we like to use:

1. If your largest room dimension is 12' or less, you can probably safely omit diffusion from the walls. Use absorption in the appropriate areas on the walls to achieve as much of an *RFZ* as possible.
2. If your control room ceiling is about 8' or higher (though I have heard rooms where this technique was used successfully on ceilings as low as 7'), you can consider diffusion for the ceiling area above the mix position – typically between the "nearfields" and the mix position. This will "open up" the sound. My personal preference is for absorption in this area, but diffusion is a completely acceptable substitute. It really comes down to style and taste. I.e.:
    a. If you mix a lot of direct-to-tape/disk music, rock and roll, punk, rap, R&B, hip-hop, techno, etc., you will probably benefit more from absorption.
    b. If you mix a lot of jazz, choral, orchestral, ensemble types of music, you will probably benefit more from diffusion.
    c. If you have a preference for the room to "not be totally dead," then go with diffusion.
    d. If you are of the "kill all the reflections…kill them now!" mindset, then it is probably obvious that your choice should be absorption.
3. For live rooms, a good smattering of diffusion mixed in with absorption is usually best, particularly on the ceiling (even if it is low). In general:
    a. Consider a 50/50 mix of absorption and diffusion on the ceiling. The diffusion is used for the "inner" ceiling – particularly over drum areas. The absorption is used more towards the walls – the "outer" ceiling.

b. Consider anywhere between 50/50 to 75/25 mix of absorption/diffusion for the walls. Use 50/50 for a more “live” room, 75/25 for a more “dead” room.

And now some “don’ts”:

4. Don’t use diffusors on the front wall of your control room, between the loudspeakers. While you may have seen this application any number of times on the cover of *MIX*, it is only because those rooms were specifically designed to incorporate diffusion there. Chances are your front wall is way too close to you to consider diffusing it. It will only smear your imaging.
5. Don’t use diffusors on a ceiling that are so thick, you will bump your head on them. For short ceilings, use low-profile (2” or so thick) diffusors.
6. Don’t use diffusors on side walls that are extremely close to the mix position. If you are not physically 8’ or more away from side walls, they should get absorbed.
7. Don’t overspend on diffusion. For small rooms, low-cost diffusors are the best course of action. There is not much point in spending more on 16 ft² of diffusors than it cost to build the room.

Auralex Diffusors

To wrap up this month, I would like to offer a brief overview of the diffusors *Auralex* offers. Links are provided for more information.

T’Fusors are our best diffusion performers. They provide excellent diffusion down to about 500 Hz at a fraction of the cost of comparably products. They are especially useful for rooms with ceiling grids since they can be dropped into a typical 2’x2’ grid.

MiniFusors are also excellent diffusors. While not as high-performing as *T’Fusors*, they offer a great aesthetic alternative in applications where something not quite so noticeable is desired.

MetroFusors are an excellent diffusor for the price. While only 2” thick (max), they provide great ambiance to a room down to roughly 1,500 Hz. They are rapidly becoming the industry standard for low-cost, high-performance acoustical diffusion.

Our brand new Q’Fusors – featured elsewhere in this month’s *Absorb This!* – are the latest and greatest addition to our diffusion line. They are the first diffusors we have developed that incorporate mathematics into the design. They provide diffusion down to about 1,000 Hz and are roughly 22” square, making them quite compatible with our new *SonoFlats*. I.e., they can be glued right to the surface of a *SonoFlat* panel to create your very own combination absorber/diffusor panel.

When placing any diffusors, remember that the more random the layout – rotating panels 45° - 180° from each other – the better results you will get. Also, filling the cavity of a *T’Fusor* or *MiniFusor* improves low frequency performance, particularly when they are mounted to a flat surface. Finally, all our diffusors can be painted to match décor. We suggest the use of a latex-based paint, sprayed on. Note that the material used for *MetroFusors* and *Q’Fusors* could react with certain paints. Testing a small area on the back of a panel is always encouraged. (If there is any bad reaction, it will happen right away.)

Conclusion

I realize that this presentation of the science of acoustical diffusion might not seem thorough to some of you. To really do diffusion justice would require a lot more space. Rest assured there will be future *Acoustology* installments on diffusion. For now – as I always suggest – absolutely contact us should you have unanswered questions on diffusion and whether it is right for you.

Next month: *Testing Standards, Coefficients and Product Comparisons*