

## The Importance Of Diffusion

By John Calder

Most of us have seen the science demonstration of how sound waves work - a pebble dropped into the calm surface of water in a tank, the slowly-radiating concentric peaks and troughs in water corresponding to cycles of compression and rarefaction in air.

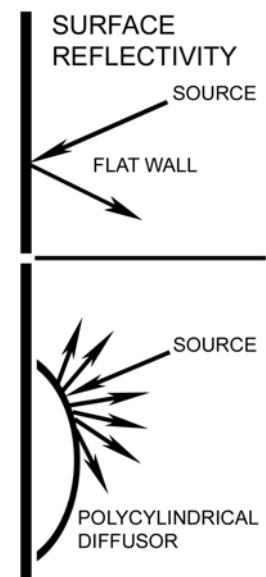
But the analogy of waves on water to sound waves in air can be misleading. While it's convenient to think of acoustical energy as radiating evenly in all directions like the pebble's waves, sound is not evenly distributed in all directions at all frequencies. Sound waves are directional, with three-dimensional radiation patterns that vary by frequency.

Likewise, flat-surfaced rooms do not distribute sound energy evenly. Sound waves reflect off flat surfaces at the same angle as they arrive, proceed to bounce off the next flat surface at the arrival angle, and continue on until dissipated by friction. These discrete single reflections result in wide variations in tonal balance and reverberation times at different room positions even a few inches apart. Parallel flat surfaces also create destructive flutter echos.

If left untreated, these two issues – sound wave directionality and flat-surface reflectivity – make for bad acoustics in rooms where sound is created, monitored, or recorded.

A common solution is to use sound absorption panels on walls and ceilings, but too much absorption causes “dead-sounding” rooms and loses the essential feeling of “live-ness”.

Creating consistent-sounding and useful acoustics is much simpler when source radiation patterns are evenly distributed and sound energy arriving at surfaces is scattered - exactly what diffusion does. With proper diffusion (ideally polycylindrical diffusers) balancing the right amount of absorption, a room will sound like it has an indefinite number of random reflections and proportional decay times, resulting in a sense of natural spaciousness.



There is another problem – when low-frequency wavelengths are whole multiples of room dimensions, they destructively cancel or add together at different positions (room modes). Where wavelengths are longer than the room's dimensions, they cannot be diffused, and standard absorption panels attenuate only mid and high frequencies. Absorbing low frequencies (20-200Hz) requires a large amount of thick absorbent material, causing space issues. The best solution is to absorb low-frequency energy with mass-loaded vinyl (MLV) membrane absorbers - these have proved to be cost- and space-efficient.

This is the most effective combination of acoustical solutions:

- Diffuse mid to high frequencies with polycylindrical diffusers
- Moderately attenuate mid to high frequencies with panel absorbers
- Attenuate low frequencies with MLV membrane absorbers

**SUMMARY:** Proper diffusion is necessary in creating natural-sounding acoustics. The right combination of diffusion and absorption results in much better tonal balance and smoother reverberation times throughout the room.