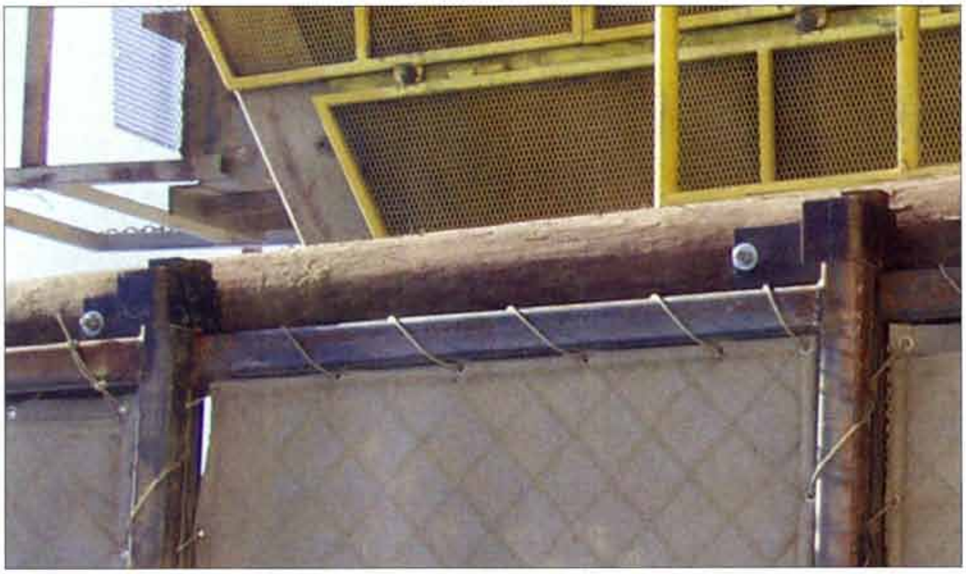
From Start to Finish
Safe and Sound Acoustics

By Nick Colleran



Acoustics are now coming into the forefront for both hearing preservation and the need for intelligibility in safety systems.

There are many references to poor acoustics in popular culture: The wife who finds the killer whale in the family pool because her husband heard "bring home Shamu" rather than "shampoo;" the folks from the '60s, when they could still hear, who remember Jimi singing "(ex)'cuse me while I kiss this guy" rather than "the sky;" and the perennial holiday cartoon of Rudolph crashing Santa into the wrong house, due to a misunderstanding of the resident's name, which won't be quoted here.

All of these are *(Continued on page 14)*

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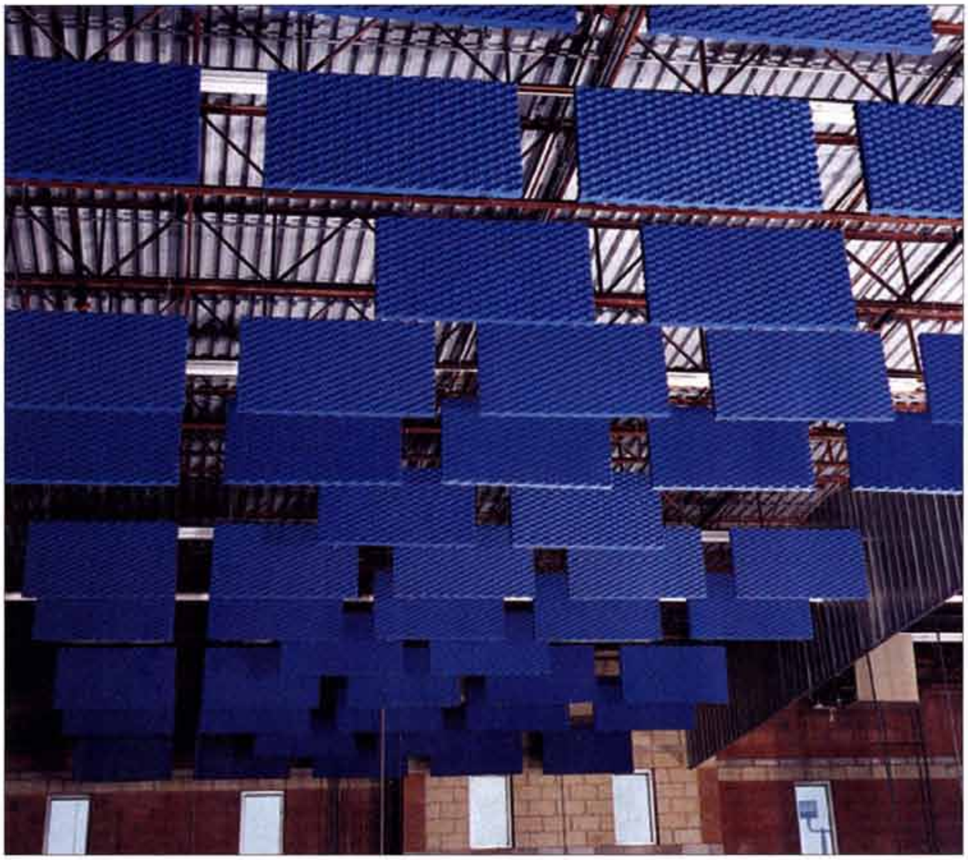

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funny but not really serious. On the other hand when the fraternity brothers in search of more to drink, raid the chemistry lab for grain alcohol and confuse "ethyl" with "methyl" the university hospital fills quickly.

Disasters of similar consequence are more likely if safety announcements cannot be heard on the job.

Two factors loom large in speech intelligibility: reverberation and noise level. In manufacturing facilities, in particular, reverberation times are reduced significantly, and at low cost, by hanging baffles with high sound absorption.

Unlike wall panels which have only one surface exposed to the environment around them, baffles are exposed on all sides, including *(Continued on page 16)*

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their edges. A sound absorption coefficient (SAC) of 1.00 is defined as one square foot of open window, one sabin of absorption per one square foot. Sound goes out-the-window never to return. A two-foot by four-foot hanging baffle, 2-inches deep, has been measured to have 17.93 sabins of absorption. Spread over 8 square feet of baffle (2' X 4') the absorption coefficient computes to be 2.25, more than twice the theoretical limit. That cannot be.

The fallacy here is using the surface area of only one side to make the calculation. Using two sides will yield 16 square feet of area, which when plugged into the calculation, is still more than 1.00, although not by much. To achieve a number within the boundaries of the possible, the edge perimeter must be included. Two-inches of edge depth over twelve feet of perimeter on a 2' X 4' baffle presents another two square feet of surface.

Correcting to a total surface area of eighteen square feet for 17.93 sabins of absorption yields a resulting sound absorption coefficient of 0.996 and is within the theoretical limit of 1.00. In layman's terms baffles are twice as efficient as the corresponding, same-size wall panel.

While baffles make the factory floor safer for the ears, not all baffles will perform equally in other regards, such as fire safety. Acoustical performance in sound absorption can be had by inserting almost any material that is porous, and has many acoustical pathways for the sound to travel and get lost.

A bale of hay will absorb sound but will not improve fire safety. None of the commercially available sound baffles are that dangerous, but they do vary in fire code rating. Having a test number as "passed" is only good if the test applies to your environment.

One test is for motor vehicles, FMVSS-302. While that test says something about the level of fire performance, it does not mean the product can be used in a high occupancy, high rise building. The product may be acceptable in a motor vehicle, but then it is also legal to have 30 gallons of gasoline in a light truck. The internal stuffing of an encapsulated hanging baffle is usually Class A. The covering has the most effect on fire resistance and cost.

Uncovered baffles made of acoustical foams are typically Class C (3) for polyurethane (usually dark gray) and Class 1 (A) for the newer cellular Melamines (usually natural white or now light gray as well). The polyurethanes "self-extinguish" (not a precise technical term), and do not continue to burn when the source of ignition is removed. Their primary concern is smoke produced. The Melamines will "char" but do not ignite.

While noise build-up may be lowered by sound baffles reducing the reverberation and echo, noise abatement is something best handled close to the source. Noise expands geometrically as it travels, and noise abatement is best handled as close to the source as possible. Absorption is a necessary component to noise control, but the "fuzzy" porous materials that absorb sound do little to block its penetration. That requires the addition of mass.

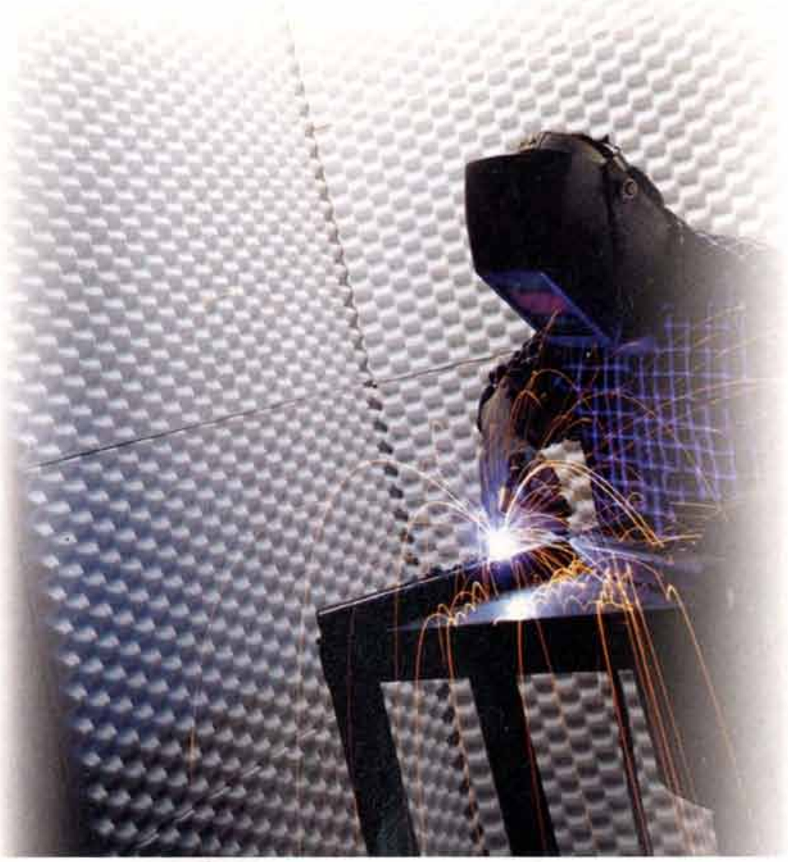
Standard building materials providing high mass include 5/8 inch "green board" and other forms of drywall (a/k/a sheetrock, gypsum board).

The items are rigid and do not provide the flexibility often needed to enclose machinery which may also move about the plant.

An acoustical, high-density material is mass loaded vinyl, sold under a variety of different trade names. This heavy vinyl has replaced sheet lead in many applications due to its flexibility. The vinyl has a high sound blocking capability (Sound Transmission Class), STC = 27 without the difficulties presented by heavy lead foil. For comparison, a two-inch thick, solid core, oak door has STC=25, but its thickness is sixteen times that of the one-eighth inch thick barrier. Vinyl barrier is used as a septum material in quilted fiberglass blankets, which must block, as well as absorb sound.

High mass barriers are required to block sound but will fail to do the job if not used in conjunction with absorbers. A standard wall constructed without insulation will pass sound since air is not trapped and will allow the opposite wall surface to vibrate much in the way that striking the top drum head causes the lower head to vibrate. Stuffing either the wall or the drum with standard fiberglass will trap the air and result in a "thud" or "thump" when it is struck, rather than a loud "boing".

Note: This is shown in science class by covering a ringing door bell with a container lined with an acoustical absorber. The *(Continued on page 18)*



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Bass from nightclubs has been known to travel through the pipes of water and sewer systems to areas where it is less desired and appreciated.

container alone still allows the ringing to be heard as the shell vibrates. The absorber alone "dulls" the higher frequencies but essentially allows most of the sound to pass through.The acoustically lined container causes the sound to drop to near a level of inaudibility.

Bad Vibrations

The numbers for Noise Reduction Coefficients (NRC)and Sound Transmission Class (STC) are useful to estimate intelligibility and overall noise levels but are averages, and do not address the low frequencies that travel through structures for significant distances.

A sound at 1000 Hz is in the speech range and has a wavelength of just over one-foot. A sound at the bottom of the audible range is perhaps more felt than heard. A vibration at 20 Hz has a wavelength approaching 60 feet and can travel through the building and down-the-road in only a few cycles.

Often the sound will be self-canceling within its own space (depending on room dimensions) but heard in adjoining structures. (This accounts for musicians not hearing themselves while neighbors hear too much. Bass from nightclubs has been known to travel through the pipes of water and sewer systems to areas where it is less desired and appreciated.) To eliminate this structure-borne noise (vibration) requires resilient de-coupling. Various isolation pads and hangers are commercially available.

With both sound and vibration control, it is essential to follow the correct installation procedures. Transmission can be made worse by one nail acting like an acoustic phonograph needle. Barriers can be breeched by holes made for alarm wiring. If air can move through the hole, so will sound.

Many sound control measures can be easily degraded by well intended workmen following normal construction techniques such as saving wire by going through, rather than around, noise barriers.

If possible, it is a good idea to have someone familiar with acoustics observe construction from start to finish. **FSM**

Nick Colleran is a member of the Acoustical Society of America, Past President of the Society of Professional Audio Recording Studios (SPARS), former president of the Virginia Production Services Association (VPSA) and is currently active in the design of new acoustical products. He now leads a "quiet life" at Acoustics First Corporation, offering suggestions to help their clients avoid the mistakes he's already made.