phoenix-E

"Creating the Better Workplace"

understanding NOISE CONTROL

technical supplement

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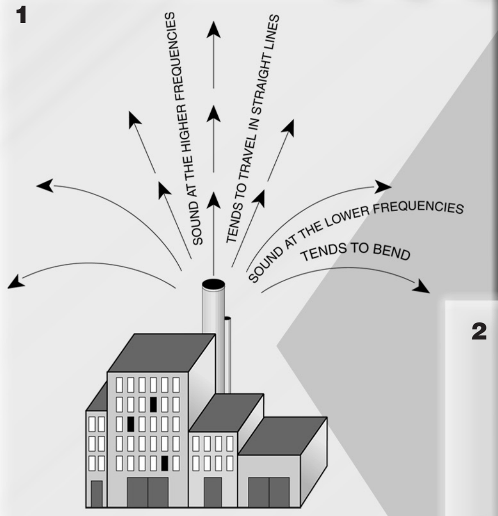

1: Sound at the higher frequencies tends to travel in straight lines and is more effectively contained by noise barriers. Low frequency energy tends to diffract at the barrier boundaries.

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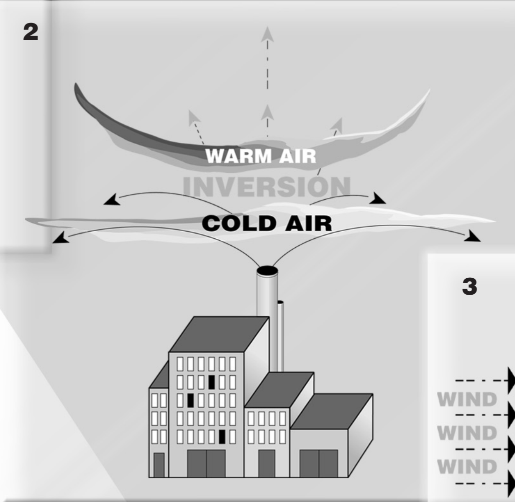
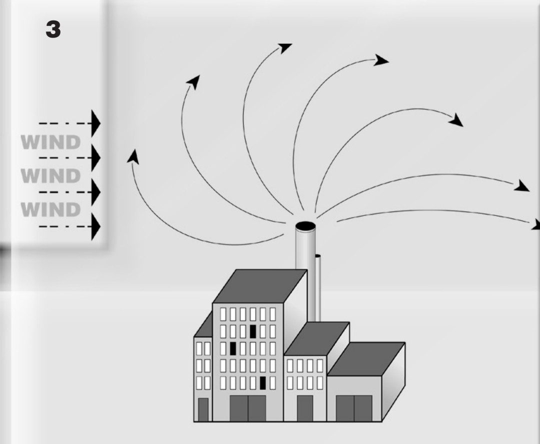


2: Sound travels faster in warmer air. Thus, warm inversion layer tends to diffract the sound downward. Additionally, high frequency sound is more readily absorbed or attenuated by the atmosphere. Low frequency noise will travel further.

3



3: Downwind of the noise source the winds will tend to bend sound towards the ground; upwind from the source, the sound is directed upwards.

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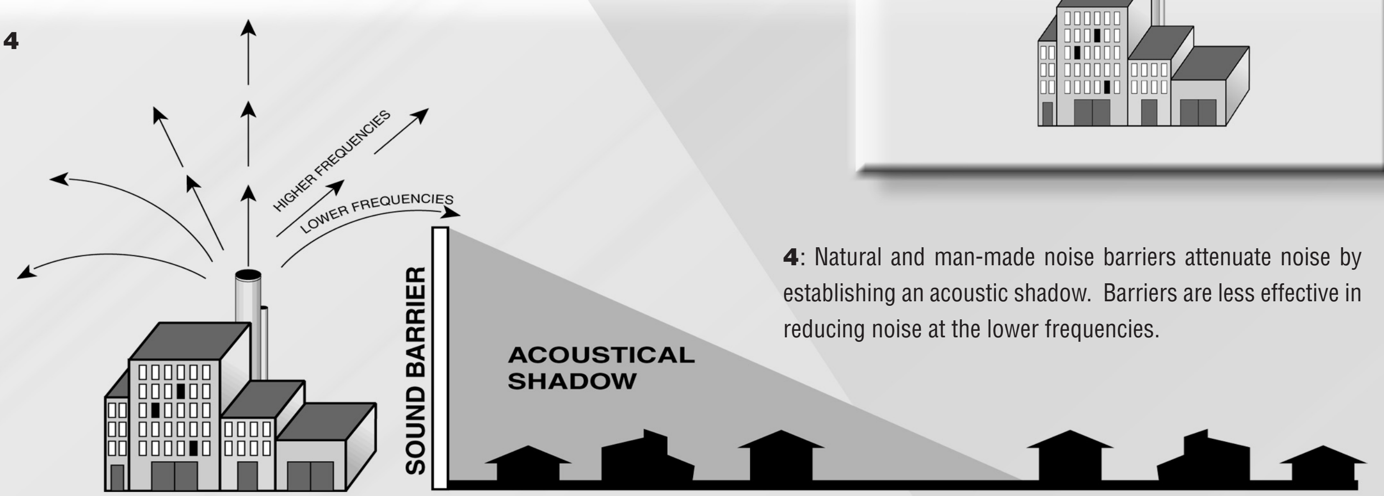


4: Natural and man-made noise barriers attenuate noise by establishing an acoustic shadow. Barriers are less effective in reducing noise at the lower frequencies.

Noise Defined

Historically, sound is one of man's most elementary tools for survival enjoying a status second only to sight for the achievements reflected in our present way of life. For some not totally understood reason, it can trigger very basic emotional as well as physical responses. Intense enough, it can shatter seemingly indestructible material. Yet, its physical properties are being harnessed and directed into tools far from the vehicle of communication it has always been: Machining, security systems, welding, metal casting, all take advantage of this energy we call "sound". Inversely, this same energy as a by-product of an industrialized society is contrary to our well being; the distinction is readily apparent by its reference as "noise".

"Noise" commonly defined, as unwanted sound is not really a new evil. The word comes from the same Latin root as does the word "nausea". Julius Caesar probably instituted the first known noise ordinance by banning chariot traffic at night.

> "Sound travels over twice as fast in aluminum as it does in air. (About 2,400 feet per second versus 1,100 feet per second)."

Silencers mitigate community blower noise.

The most obvious malady of excessively high noise levels is, of course, hearing loss. However, noise produces other adverse effects in the human body. According to independent medical studies, "with exposure to high noise levels, the blood vessels constrict, the skin pales, the pupils dilate, the eyes close, and the voluntary and involuntary muscle tense." Adrenaline is suddenly injected into the blood stream which increases neuromuscular activity, tension, nervousness, irritability, and anxiety.

It is as if the body is shifting gears with a corresponding rise in blood pressure. People do not get used to sudden or loud noises; instead, our bodies react as if these sounds are a signal of danger or threat preparing us for physical activity. Interestingly, these biological changes occur whether we are awake or asleep. While the noise does not have to be loud enough to cause hearing damage, it can cause regular and predictable changes in the body.

Some psychologists believe teenagers exposed to loud music which can approach 130 dBA and industrial workers exposed to high equipment noise levels who believe they "can take it", are both actually under a narcotic effect, that they are overwhelmed by a noise that "blots out all else in the world and like marijuana enables them to escape temporarily from reality."

If our bodies are kept in a near state of agitation, the cumulative effects may result in automatic responses which build on each other leading to what researchers term "diseases of adaptation". These diseases of stress include ulcers, asthma, high blood pressure, headaches, and colitis. Chronic noise must be assumed to be pathological with constant exposure negative to your health.

Even the fetus is capable of perceiving sounds and responding to them by motor activity and cardiac rate change. Noise has been linked to low birth weights though it cannot be said at what level maternal exposure to industrial noise is dangerous to the fetus.

Other adverse effects of high noise levels are its impact on the classroom and the educational process, interference with conversation and social interaction, sleep disruption, and the masking of audible warnings of pending danger.

There is much ongoing research as to the effects of noise on the human body to fully diagnose the physiological and psychological symptoms that appear to be suspect. As with ailments attributable to other forms of pollution, such studies will reduce the negative impact of noise on our quality of life and lifestyle.

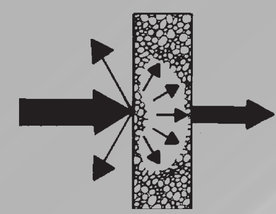
Sound is simply a series of vibrations. It is the result of a series of compression and, then, expansion of molecules. This energy is audible to the human ear at frequencies between 20 Hz and 20,000 Hz. It travels best and for longer distances through dense materials. At the lower frequencies, it is very pervasive, the sound waves bending or diffracting readily around structures and easily passing through many conventional materials. At the higher frequencies, it behaves much like light, tending to travel in straight lines and is relatively easy to control with absorption and barrier systems.

Although there is no exact and universally accepted point at which sound is perceived as noise, potential hearing damage due to noise is an accepted and recognized occupational hazard. The extent of damage depends on the length of time exposed, the intensity, and the exact nature of the noise.

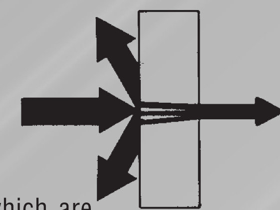
Acoustical Enclosures Reduce Noise of Water Treatment Systems.

There are three basic ways to reduce noise in most applications:

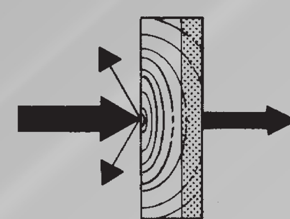
1. ABSORPTION: Materials that absorb noise have an open fibrous structure that allows sound to enter. These strands vibrate which, in turn, converts the mechanical energy into minute amounts of heat. Absorbing materials are used to reduce reverberant noise build-up from inside rooms or equipment enclosures.



2. BLOCKING: Certain materials are quite effective in providing a barrier to block the noise. These do not absorb or deaden the sound but reflect or contain it depending upon how the materials are used. Effective materials have high density or mass among other somewhat more technical considerations.



3. DAMPING: Materials which are vibrating are sometimes re-radiating this energy as sound by driving the air adjacent to their surface. Damping materials are applied directly to the vibrating surface and convert this energy directly into heat via minute deflections.



Where is the best place to locate the noise control system or equipment? In many cases, the plant operations will dictate where it can be placed so as to minimize any impact on production. But, in order of effectiveness, noise control measures are implemented by controlling the noise at its source, altering the noise path, or protecting the personnel.

> "The sharp sound of an exploding fire cracker and the gentle sound of rustling leaves which originate at the same place and time will reach any other point simultaneously."

Background noise and communications

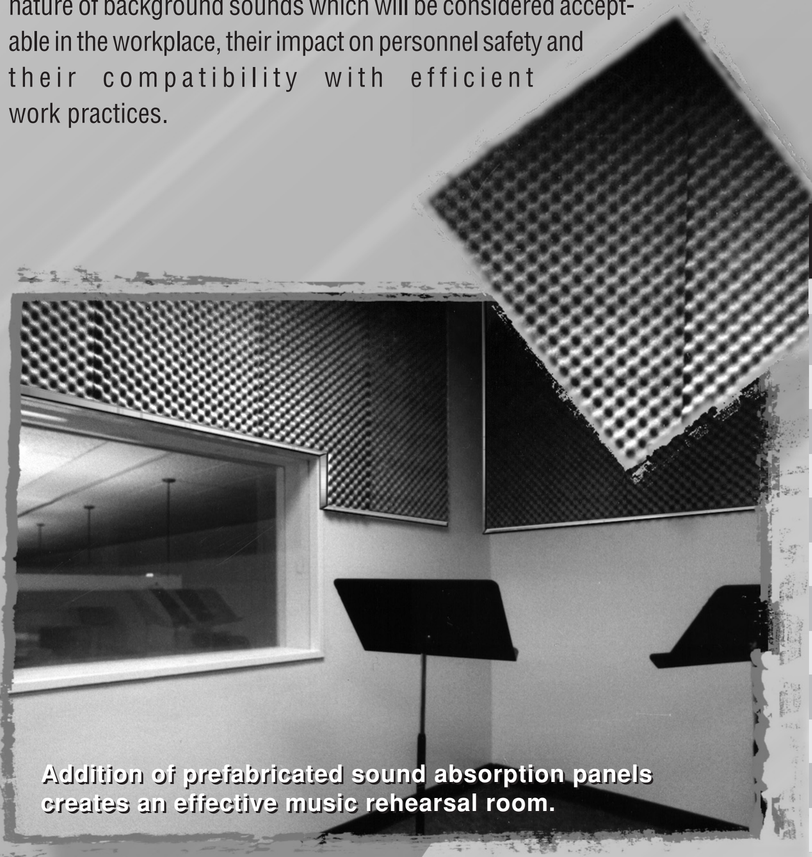
Acoustical privacy and effective communications are both dependent in part on steady-state background noise levels. While speech intelligibility is optimized by reducing distracting or loud sounds, privacy is sometimes enhanced by the addition of certain types of background sounds.

Steady-state noise from air-conditioning equipment, music or the continuous din of machinery noise will mask employee conversations particularly where partitions and walls have low transmission loss values. Where sound isolating constructions are lacking, acoustical privacy can be enhanced by adding background sound at levels ranging from NC 30 to NC 40.

For enhancing the intelligibility of speech, guidelines have been established to minimize sound levels especially in the important speech frequencies of 500 Hz, 1000 Hz, and 2000 Hz. The **Preferred Speech Interference Level* (PSIL)** is an average of the sound pressure levels in each of these three octave bands as measured in decibels. It has been used to quickly estimate the permissible acceptable background sound levels for effective communications.

** PSIL = dB (500Hz) + dB (1000 Hz) + dB (2000 Hz) ÷ 3*

Suggested **PSIL** for personnel communications and telephone use are shown in Figure 1 and Figure 2. These recommendations must be considered with respect to the nature of background sounds which will be considered acceptable in the workplace, their impact on personnel safety and their compatibility with efficient work practices.



Addition of prefabricated sound absorption panels creates an effective music rehearsal room.

Figure 1

TELEPHONE	COMMUNICATIONS
BACKGROUND NOISE (PSIL)	INTELLIBILITY
< 63 dB	GOOD
63 dB to 78 dB	FAIR-TO-POOR
78 dB to 83 dB	VERY POOR
> 83 dB	DIFFICULT OR IMPOSSIBLE

Figure 2

BACKGROUND SOUND LEVELS FOR CONVERSATIONAL SPEECH-PSIL		
DISTANCE TO LISTENER	BACKGROUND NOISE LEVEL	DIFFICULTY
16 feet	40 dB	Normal Voice
8 feet	50 dB	Normal Voice
3 feet	60 dB	Normal Voice
1 foot	70 dB	Normal Voice
1 foot	80 dB	Raised Voice
1 foot	90 dB	Shout
½ foot	100 dB	Shout
½ foot	110 dB	Unitelligible

Figure 3

NOISE CRITERION (NC) CURVES & CORRESPONDING SOUND PRESSURE LEVELS (decibels)								
	Octave Band Center Frequency (Hz)							
NC Curve	63	125	250	500	1000	2000	4000	8000
15	47	36	29	22	17	14	12	11
20	51	40	33	26	22	19	17	16
25	54	44	37	31	27	24	22	21
30	57	48	41	35	31	29	28	27
35	60	52	45	40	36	34	33	32
40	64	56	50	45	41	39	38	37
45	67	60	54	49	46	44	43	42
50	71	64	58	54	51	49	48	47
55	74	67	62	58	56	54	53	52
60	77	71	67	63	61	59	58	57
65	80	75	71	68	66	64	63	62

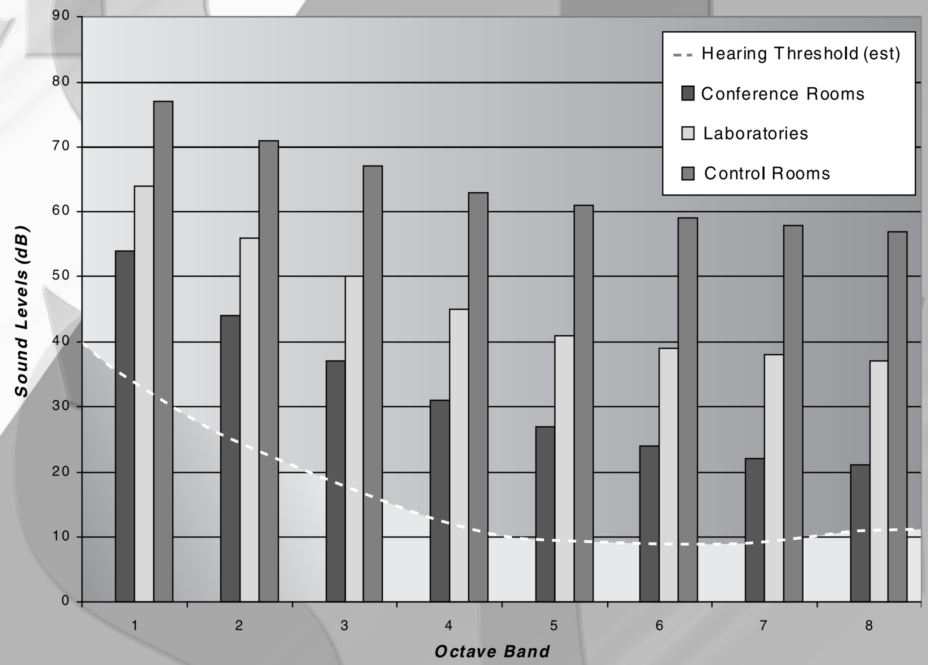
Room use or occupancy

A variety of standards and suggestions have been used to establish objectives for the design of ideal acoustical environments for various uses of architectural space. Associating particular functions for use with optimum background noise levels is indeed important in most instances but can be critical in others. Acoustical consultants are concerned with not only intelligibility — the ability to understand or comprehend — but also with the quality of the acoustical environment which can enhance the efficiencies of public and private space.

For many common occupancy uses, the background noise levels determine whether the occupants will find the space acceptable. And, while many criteria are available for use in the acoustical design of critical space applications, **NC curves (Noise Criteria)** developed many years ago, simple to understand and apply, are still commonly used to suggest steady background noise levels for typical everyday environments.

TYPICAL MAXIMUM BACKGROUND NOISE LEVELS

Acceptable Background Noise Levels Vary With The Intended Use Of Space



Decibels are a logarithmic ratio: For instance an increase in the sound pressure level of 3 decibels represents twice the sound intensity. And an increase of 10 decibels represents ten times the sound intensity.

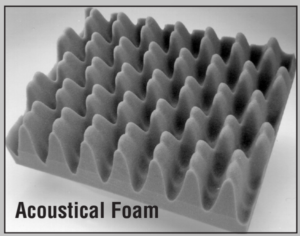
TYPE OF SPACE ACOUSTICAL REQUIREMENT	SUGGESTED NC CURVE	ESTIMATED EQUIVALENT dBA LEVEL
Broadcast and recording studios (distant microphone pickup only).	15-20	25-30
Broadcast, television, and recording studios (close microphones pickup only).	20-25	30-35
Small auditoriums, small theatres, music rehearsal rooms, large meeting and conference rooms or executive offices.	25-30	35-40
Private or semiprivate offices, small conference rooms (for good listening conditions).	30-35	40-45
Large offices, reception areas, retail shops and stores, cafeterias, restaurants and so forth (for moderately good listening conditions).	35-50	45-60
Lobbies, laboratory work spaces, drafting and engineering rooms, general secretarial areas (for fair listening conditions).	40-45	50-55
Light maintenance shops, office and computer equipment rooms (for moderately fair listening conditions).	45-60	55-70
Power-plant control rooms, shops, garages (for acceptable speech and telephone communication).	50-60 (est.)	60-75 (est.)

Solving noise control problems

There are three basic areas to examine when first confronted with a noise control problem: (1) the noise source (2) the noise path (3) the noise receiver. For any application, each should be evaluated to determine which will be the effective and most direct solution to achieve the needed noise reduction.

Approach One — Source Control

The most desirable approach to noise control is to reduce noise at its source. At the source, the addition of acoustical material can significantly reduce the noise level. Foam, mineral wool and fiberglass are effective sound absorbers because their porous structure soaks up sound. These materials absorb noise by dissipating the sonic energy into small amounts of heat.



Acoustical Foam

Approach Two — Path Control

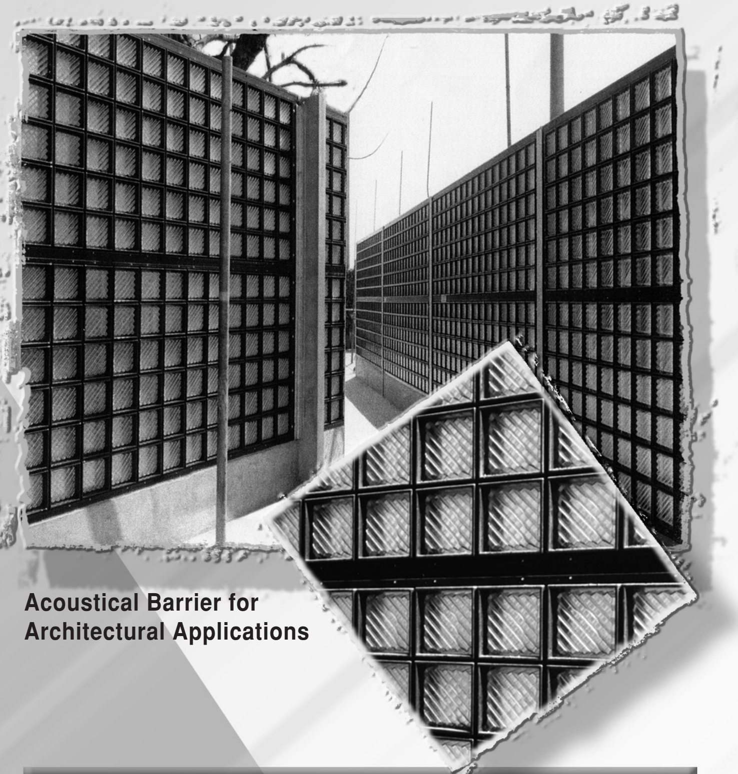
Sound absorbing ceiling baffles & wall panels

Noise is transmitted via sound waves. Altering the path of the transmission to reduce the amount of acoustical energy that will reach the industrial noise control. Usually, this involves impeding the sound transmission by interfering with its reflected and direct paths. Reflected noise paths can be reduced by adding sound absorbing panels to walls and by hanging unit absorber arrays from ceilings. Direct noise paths can be disrupted by using enclosures or acoustical barrier walls between the source and receiver. These barriers are most effective when used in combination with materials designed to treat reflected sounds.

Approach Three — At The Receiver

Ear plugs or earmuffs are considered highly economical methods for reasonable effective receiver noise control. However, employees are often uncomfortable having to constantly wear these devices. They note their inability to detect changes in the sound of their equipment, their inability to communicate with others and hear sirens or other audible warnings. Additionally, OSHA regulations state that ear protection must be used as a last resort only after exhausting "feasible administrative or engineering controls..." Quiet zones or personnel enclosures are preferred to reduce the noise level that reaches the receiver.

Quiet Control Room



Acoustical Barrier for Architectural Applications

> "Crickets' chirps heard a half mile away have passed through about a thousand pounds of air."

THE USE OF ENCLOSURES

Maximum noise control is provided by quality sound enclosures because they normally include materials and design features which provide sound absorption, transmission loss, sealing, and ventilation in one system. Noise is blocked from either entering or leaving the enclosure. This provides the option of either enclosing the noise source or the noise receiver.

Enclosures must be properly designed. Adequate sealing is required for an enclosure to maintain its acoustic integrity. Access doors, windows and ventilation systems can pose special challenges. The enclosures' ventilation system may require silencing of the intake and exhaust paths. In cases where a manufacturing process requires materials to be constantly moved in and out of an enclosure acoustic tunnels or shields must be incorporated into the design to ensure acoustic integrity.

Portable Sound Isolation Rooms

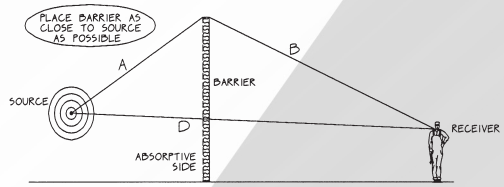
Soundwalls

Often used outdoors, acoustical barriers provide an economical technique to reduce community sound levels from equipment , process and traffic noise.

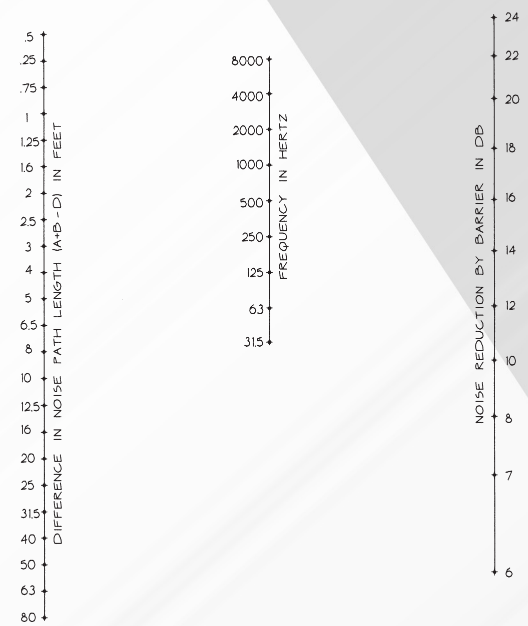
Indoors, noise barriers can reduce the noise levels in adjacent areas while often eliminating the need for additional ventilation, lightning, and fire protection typically incorporated into many acoustical enclosures. Accessibility to equipment and process is also enhanced. Interior applications require careful evaluation of the existing constructions; reverberant areas and reflective surfaces can rapidly reduce their performance.

The nomograph shown in figure 4 provides a general guide in barrier performance under ideal conditions as a function of frequency. Barriers perform best at attenuating energy in the higher frequencies.

SOUND BARRIER PERFORMANCE



THE KEY DIMENSIONS IN ESTIMATING BARRIER ATTENUATION ARE THE STRAIGHT LINE DISTANCE BETWEEN THE SOURCE AND THE RECEIVER (D) AND THE SHORTEST PATH AROUND THE BARRIER (A+B)



NOMOGRAPH TO ESTIMATE BARRIER ATTENUATION

* NOMOGRAPH ASSUMES FREE FIELD CONDITION. (EXTERIOR INSTALLATION) IN INTERIOR APPLICATIONS THE NOISE NOT ONLY DIFFRACTS, BUT REFLECTS OFF CEILINGS AND WALLS.
* NOMOGRAPH VALID ONLY FOR POINT SOURCES. LARGE NOISE SOURCES OR LINE SOURCES REQUIRE SPECIAL ENGINEERING
* NOMOGRAPH CONSIDERS ONLY ONE EDGE FOR DIFFRACTION. IF THE LENGTH OF THE BARRIER IS NOT 3 TIMES THE HEIGHT, THE LATERAL EDGES MUST BE CONSIDERED.

OSHA Regulations

The OSHA Permissible Exposure Level (PEL) of 90 dBA is an effective Hearing Conservation Program for those employees exposed to an 8-hour Time Weighted Average (TWA) of 85 dBA or greater. The program includes (a) monitoring employee noise exposure, (b) annual audiometric testing of employees exposed at or above a TWA of 85 dBA, (c) proper selection of hearing protectors, (d) education and training of employees, (e) warning signs and (f) records of monitoring and audiometric testing.

The following are excerpts from 29 CFR1910.95:

“(b) (1) When employees are subjected to sound exceeding those listed in Table G-16, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels of Table G-16, personal protective equipment shall be provided and used to reduce sound levels within the levels of the table.”

NOTE: Administrative control means job rotation to reduce noise dose. Engineering control means work site noise reduction, noise control, to reduce dose.

Table G-16 — Permissible Noise Exposures[1]

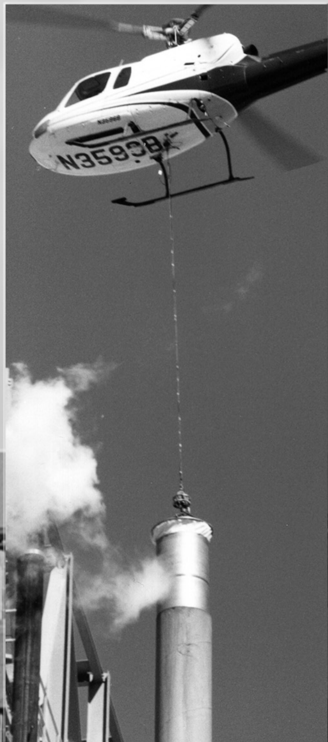
Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
$1^1/_2$	102
1	105
1/2	110
1/4 or less	115

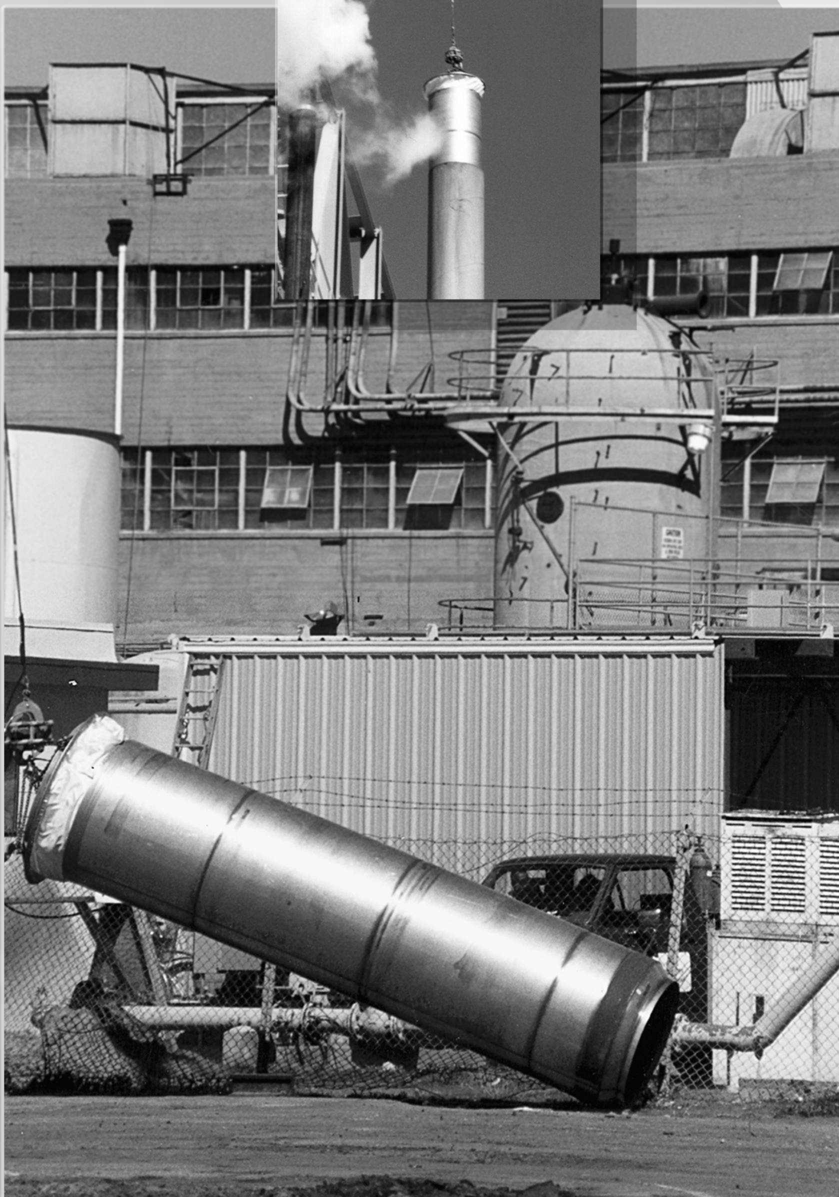
[1]When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each.

Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

Hospital Cooling Tower Soundwall

Creative Engineering





While many noise control applications require only that standard acoustical materials or equipment be used properly for a successful solution to an in-plant or community noise problem, some projects require developmental efforts, innovative engineering and planning before any fabrication and installation can begin.

At a plant utilizing a wet scrubber, a resident of the adjacent community complained of the noise levels, threatened to move, and enter into litigation with our client. Several sound surveys indicated that the sound levels peaked at approximately 98 dBA at the blower stack discharge; further, there was a discrete tone at approximately 500 Hz. It was this pure tone that the local resident agreed was causing his discomfort.

The most apparent way to solve an air handling noise problem is to install a silencer at the system discharge. However, the stack discharge was at an elevation of 135 feet above the ground. Surrounding building structures prohibited the use of a crane to lift such a unit into place. Because the stack was eccentric due to the varying exhaust gas temperatures, it was impractical to weld companion flanges on the stack to accept the silencer. Lastly, the stack was not designed to handle any additional significant loading without expensive structural modification.

The solution: **PHOENIX-E STRUCTURES** designed a lightweight (3,000 pounds) 20 feet long "Silencer Insert" of all stainless steel construction. By using the shell of the stack for structural support as well as for the outer wall of the silencer, the weight of the unit was minimized and the additional weight was maintained near an existing support which proved structurally acceptable. The acoustical seals were designed to operate automatically once the unit was in position. And the weight of the silencer made further welding or bolting unnecessary.

The installation phase of the project was the most exciting. A helicopter was used to lift the silencer and set it into the stack. Total time was less than five minutes.

Post installation acoustical measurements showed the sound levels emanating from the stack were less than the ambient. The resident still lives nearby and he sent a letter of appreciation to the company.

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